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FISCAL YEAR 1987 DEPARTMENT OF ENERGY AUTHORIZATION

(Conservation and Renewable Energy)

m-197

HEARINGS
BEFORE THE
SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS
OF THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-NINTH CONGRESS
SECOND SESSION

ORIGINAL

COMPLETED

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FEBRUARY 27; MARCH 6, 1986

[No. 89]

VOLUME III

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Committee on Science and Technology

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*Ranking Republican Member.
**Serving on Committee on the Budget for 99th Congress.

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1987 DEPARTMENT OF ENERGY AUTHORIZATION

THURSDAY, FEBRUARY 27, 1986

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:40 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Hall, Walgren, Sensenbrenner, Schneider, Packard, Fawell, Barton, and Slaughter.

Staff present: William T. Harvey, Jr., staff director.

Mr. **Fuqua**. The subcommittee will be in order.

This is the first of several hearings we will hold on the Department of Energy's fiscal year 1987 authorization budget. Today, we will hear from the Department on both conservation and renewable energy program requests and from other witnesses on the renewable energy aspect only. In a later hearing, we will review the conservation budget with witnesses who are from outside the Department.

In reviewing the programs in conservation and renewable energy, we see the need for considerable discussion. First, the reduction from appropriated fiscal year 1986 levels of 58 percent for the Conservation R&D Program and 47 percent for the Solar and Renewable Programs is quite substantial. This raises the question as to whether long-term goals and objectives will be met, both through this reduction and possible similar action in subsequent years.

It is noted that the fiscal year 1987 Conservation Program also plans to carry forward over $36 million as deferrals. This would mean that we really are not through with the fiscal year 1986 budget, although the programs planned for deferral were enacted into legislation and signed by the President only a little more than 4 months ago. We wonder how long this process is going to continue.

A new term used in both the conservation and renewable energy budget requests is the Cooperative R&D Venture. This intent has limited Federal funds through cost-sharing with others for R&D activities of meaningful sizes, and it is attractive to all of us. We see that kind of leverage used effectively elsewhere; however, descriptions of this concept are kind of long on verbiage and rather short on substance. We may have to find a great amount of interest by industry in such joint undertakings, but that interest probably will not be evident until DOE defines the terms and conditions that they're talking about. It seems incumbent on DOE to try to spell out that interest.

Fiscal 1987 is unlike any other that we have addressed. This is the first year that the Congress and the administration are faced with a deficit ceiling. The method of getting from here to there at the present time is not totally defined, and there is a possibility that, under the Hollings-Rudman-Gramm Act, that the Congress could pass legislation providing for more equal reductions to the fiscal year 1987 level, compared to the fiscal year 1986 appropriations that have been proposed here and in other programs. We will certainly be interested to learn of the contingent plans which DOE has in place or planned for the future, just in case reductions would be less stringent than provided in these requests.

Based on our input and guidance, we have asked outside witnesses to look at the fiscal year 1987 budget as though it was reduced from the fiscal year 1986 levels by a nominal 15 percent, which was mandated by the Hollings-Rudman-Gramm Act. There is nothing fixed or certain about this reduction activity, but it will give us some idea of participants' and observers' feelings for the budget, its priorities, and funding levels at that reduced amount.

As mentioned earlier, we do have a number of questions relative to these budgets. We have a lot of witnesses today, and at a later time in the very near future all of this is going to be helpful in trying to come up with an appropriate legislative activity.

[The prepared opening statement of Mr. Ralph Hall follows:]

OPENING STATEMENT OF RALPH M. HALL

Mr. Chairman and members of the committee, I want to thank the Chairman for convening this series of hearings to review the fiscal year 1987 budget of the Department of Energy in the areas of fossil, conservation, renewables and basic energy research programs.

This work that the department does in these areas has been and continues to remain important to the national interest. As you know, Mr. Chairman, I and other Members have had some concern for quite some time over the Crosbyton Solar Power Project being conducted by Texas Tech University in Lubbock. My concern, as well as that of Mr. Stenholm, Mr. Combest and the other members of this Committee from Texas, has centered primarily on whether the project, which is a solar bowl concept, will be evaluated by the Department on a basis consistent with the other solar thermal technologies.

We are currently having some discussions with the Department on the future of that project, and it appears we may be on the way to making some progress on reaching a reasonable resolution of the outstanding issues. Further discussion needs to take place between the Department and the Project over the next few weeks, and I hope they will be concluded to everyone's satisfaction. Therefore, I will not take up the Committee's time with questions related solely to this project, but at the appropriate time, I would like to make a unianimous consent request that the Department appear before the Committee at the markup on March 19 and give us a report on the outcome of the discussions.

Thank you Mr. chairman, and I yield back the balance of my time.

Mr. FUQUA. Mr. Sensenbrenner, do you have anything?

Mr. SENSENBRENNER. Not for now, thank you, Mr. Chairman.

Mr. **Fuqua**. OK.

Our first witness is Ms. Donna R. Fitzpatrick, Assistant Secretary for Conservation and Renewable Energy; and she is accompanied by Alan J. Streb, Assistant Secretary for Conservation, and Bob San Martin, Deputy Assistant Secretary for Renewable Energy. We welcome all of you people here today; Secretary Fitzpatrick, we'd be just delighted to hear from you at this time.

STATEMENT OF HON. DONNA FITZPATRICK, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY ALAN J. STREB, DEPUTY ASSISTANT SECRETARY FOR CONSERVATION, AND ROBERT L. SAN MARTIN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE ENERGY

Ms. **Fitzpatrick**. Thank you, Mr. Chairman.

I have a detailed statement I would like to submit for the record, and if I may, I'd like to summarize it orally here.

Mr. **Fuqua**. Yes. We will make the prepared statement a part of the record, and if you wish to summarize, that would be fine.

Ms. **Fitzpatrick**. Thank you.

Mr. **Fuqua**. The only request we make on summaries is that they are shorter than the prepared statement. [Laughter.]

Ms. **Fitzpatrick**. Substantially so, Mr. Chairman.

Mr. **Fuqua**. I think that applies to all the witnesses. Sometimes that doesn't happen.

Ms. **Fitzpatrick**. I will comply, Mr. Chairman.

First of all, let me say I am happy to see you restore Senator Hollings to his rightful place of honor. It has been said that Gramm-Rudman-Hollings itself took a cut and became only Gramm-Rudman, but he deserves to be credited with that, too.

I appreciate the opportunity to appear before you today to discuss the fiscal year 1987 budget request for the Conservation and Renewable Energy Programs at the Department of Energy. The budget for these programs is consistent with the goals and objectives of national energy policy and is fully responsive to the administration and congressional goals of deficit reduction.

The administration's overall energy goal is to foster an adequate supply of energy at reasonable cost. Achieving this goal will require that we make use of our Nation's vast natural resources and the daring and ingenuity of its citizens. Our approach includes supporting advances in energy conservation, as well as possible energy supply sources of the future, including renewable energy.

Deficit reduction is perhaps the preeminent domestic economic imperative today, and the Department fully recognizes that fact. For this reason, we are doing all we can to concentrate our increasingly scarce resources on those programs and projects that directly fulfill a responsibility of the Federal Government and truly require Federal assistance. If we are to achieve our overriding goal of deficit reduction, we have no choice but to concentrate our resources where they show promise of bringing the greatest benefits. We have tried to do this without sacrificing the essential goals of each of our research programs.

As we seek ways to gain the greatest benefit from our limited resources, we will investigate cooperative research and development ventures with private industry consortia. This approach to R&D funding has the potential to provide greater leverage of Federal resources and more effective technology transfer.

We have had a number of successes in the last year; and in order to continue to contribute to the achievement of our goals, the fiscal year 1987 budget request for energy conservation and renewable energy R&D programs will continue to support the development of a mix of technologies that can contribute to both energy supply and improved end-use efficiency.

I'd like to briefly summarize for you our budget requests in each of the major program areas, beginning with our energy conservation programs.

The 1987 budget request for energy conservation R&D under this subcommittee's jurisdiction totals $49.2 million. It includes work in buildings and community systems, industrial programs, the multisector programs—including energy conversion and utilization technologies—and policy and management.

Let me give a few examples of the types of activities that will be undertaken in fiscal year 1987.

In the buildings and community systems programs, we will continue our investigations of how to maintain acceptable air quality in energy-efficient buildings. These efforts include studies of radon entry and mitigation methods and the generation and distribution of biological aerosols.

In cooperation with industry, we will continue research to advance the technologies supporting thermally activated heat pumps and advanced lighting, as well as continuing the utility least-cost planning initiative.

The budget request for industrial programs will be used to continue research, including thin strip casting, high temperature recuperators in heat pumps, advanced sensors, process controls, direct thermal-to-electrical conversion, waste conversion, and several advanced separation processes, including membranes.

The fiscal year 1987 budget includes the Energy-Related Inventions Program, which was established to evaluate the technical merits of energy-related inventions submitted to DOE and to provide technical assistance and grants to further develop promising inventions. From the program inception in 1974 through 1985, approximately 22,000 energy-saving inventions have been evaluated. The 1987 request will provide funding for evaluating roughly 1,000 inventions, and providing technical assistance and grants to approximately 22 inventors.

In the Multisector Program, we plan to complete experimentation and modeling for the joining of ceramics to ceramic surfaces, and ceramic to metal joints, which is an important element in providing reliable ceramic engines using new microwave heating techniques.

The fiscal year 1987 budget request also provides for continued investigation, in theory and experiment, to expand our understanding of the relationships between bonding and structure at the atomic level in selected materials related to conservation. One of the possible results of this work could be the development of new, very high temperature materials which are not yet known.

In the State and Local Assistance Programs, as a result of the recent Supreme Court decision in the Exxon Oil overcharge case, approximately $2.1 billion is being distributed to the States and territories for use in five energy grant programs, including the Energy Extension Service. An additional $750 million is expected to be made available to the States later this year in the Stripper Well cases. Therefore, the Department is requesting no appropriated grant funds for the conservation grant programs. We have requested $5 million to cover DOE headquarters and field office salaries and expenses which are required for administering existing Federal grants and providing technical assistance to the States and territories.

I'd like to move to our Renewable Energy Programs. Renewable energy is an important part of the Nation's energy supply mix; in fact, renewable energy is already contributing more than 8 percent of the total energy consumed in the United States. In certain locations, the contribution is even greater. For example, 15 percent of all water heaters in Hawaii are solar, and 8 percent of new electric generation capacity in California is renewable.

When the Federally supported Renewable Energy Program began in 1974, most of the technologies were either in the conceptual stage or they existed in rather primitive forms. During the past decade we have made major advances in all of the renewable energy technologies. New materials have been developed with thermal, optical, and physical properties which are required for lower costs and higher performance. New components have been tested and substituted for less effective ones. Extensive systems analysis has been performed, and hundreds of systems have been studied under both controlled laboratory conditions and typical field operations. Teams of scientists and engineers in Government laboratories, universities, and industry have created a solid technology base and expertise in the broad array of disciplines pertaining to renewable energy technologies.

As the various renewable energy technologies continue to develop, their economic and technical viability will improve, along with their collective contribution to the Nation's energy needs. In order to support this development, our renewable energy R&D program will continue to address a range of fundamental issues. These issues include basic materials related work on the structural integrity of reflective surfaces, and the conversion efficiency of photovoltaic materials; resolution of wind technology reliability, and durability issues through advancement of the underlying structural understanding and aerodynamic theory.

We need to resolve the environmental uncertainty which still attends the combustion of municipal wastes and other biomass feedstocks, and the feasibility of using magma energy as a geothermal energy source for power generation.

Our proposed budget for support of renewable energy programs under this committee's jurisdiction totals $91.9 million.

Mr. Chairman, I believe this budget will contribute to increased energy supply diversity and end-use efficiency and will serve to promote increased competition in the marketplace. This budget request maintains our program goals and it will allow us to address the items of highest priority in research and development in the fields of energy conservation and renewable energy, thereby contributing to the accomplishment of our national goal of fostering an adequate supply of energy at reasonable cost.

This is a budget which I believe seriously recognizes today's fiscal responsibilities, as well as tomorrow's anticipated needs; and it will build on the foundation of energy stability and security that we, working with the Congress, have laid in the last few years.

Mr. Chairman, we are pleased to have the advice we have received from the Congress, and in particular this subcommittee, and we thank you for the opportunity to appear here today.

[The prepared statement of Ms. Fitzpatrick follows:]

STATEMENT OF

DONNA R. FITZPATRICK

ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

FEBRUARY 27, 1986

Mr. Chairman and Members of the Subcommittee:
I appreciate the opportunity to appear before you today to discuss the FY 1987 budget request for the Conservation and Renewable Energy programs of the Department of Energy. The budget for these programs is consistent with the goals and objectives of national energy policy and is fully responsive to the Administration and Congressional goals of deficit reduction.

The Administration's overall energy goal is to foster an adequate supply of energy at reasonable cost. We can achieve that goal through the combination of energy stability, energy security, and energy strength. Energy stability has been achieved over the past five years. Our energy security is growing stronger day by day. Our objective for the immediate future is to build this Nation's energy strength, making full use of its vast natural resources and the daring and ingenuity of its citizens. Our approach includes supporting advances in energy conservation as well as possible energy supply sources of the future such as renewable energy.

Deficit reduction is perhaps the preeminent domestic economic imperative today and the Department fully recognizes that fact. For this reason, we are doing all we can to concentrate increasingly scarce resources on those programs and projects that directly fulfill a responsibility of the Federal government and truly require Federal assistance. If we are to achieve our overriding goal of deficit reduction we cannot afford to continue to allocate scarce Federal resources to activities where the rationale for continued Federal involvement is weak and where State and local organizations or private industry can and should take over responsibilities presently borne by the Federal government. Also, we cannot permit programs or projects to continue with Federal support unless they meet a high priority national need. We have no choice under the current and necessarily strict fiscal regimen but to concentrate scarce resources where they show promise of bringing the greatest benefits.

As we seek ways to gain the greatest benefit from our limited resources, we will investigate cooperative research and development ventures with private industry consortia. This approach to R&D funding has the potential to provide greater leverage of Federal funds and to assure that resources for applied R&D are focused on high priority areas where there is private commitment to follow through with promising technologies. It can also foster increased technology transfer by involving industry earlier in the R&D sequence. One of our early steps will be the publication of a general solicitation of industry interest in forming R&D ventures in the various conservation and renewable energy program areas.

In order to contribute to the achievement of our goals, the FY 1987 budget request for energy conservation and renewable energy research and development (R&D) programs will continue to support development of a mix of technologies that can contribute to both energy supply and improved end-use efficiency. The FY 1987 budget request for Conservation and Renewable Energy programs under this subcommittee's jurisdiction totals

$145.9 million; $54.2 million for energy conservation programs, and $91.7 million for renewable energy R&D programs (see attached table). I would like now to discuss each of our major program areas under the Office of Conservation and Renewable Energy and its related FY 1987 funding request.

FY 1987 BUDGET REQUEST FOR ENERGY CONSERVATION R&D

The FY 1987 budget request for energy conservation research and development programs under this subcommittee's jurisdiction totals $49.2 million. It includes $11.9 million for Buildings and Community Systems, $15.6 million for Industrial Programs, $19.8 million for Multi-Sector Programs, and $1.8 million for Policy and Management.

Buildings and Community Systems

The buildings sector accounts for approximately 36 percent of our total national energy consumption. In residential buildings, space heating, water heating, and refrigeration use the largest amounts of energy; in commercial buildings, space heating, lighting, and air conditioning use the largest amounts. Significant energy savings can be achieved by improving the efficiency of these and related building functions. Our Buildings and Community Systems program conducts research to establish a technology base upon which industry can build to make these savings possible and makes the results of that research available to the private sector. This program also implements mandated building energy regulatory programs. We are requesting $14.1 million for these research, technology transfer, and regulatory activities in FY 1987.

CONSERVATION AND RENEWABLE ENERGY
(dollars in thousands)

PROGRAM	FY1987 CONGRESSIONAL REQUEST
RENEWABLE:	
GEOTHERMAL	$17,930
SOLAR ENERGY:	
BUILDINGS	4,700
PHOTOVOLTAICS	19,600
THERMAL	15,300
BIOFUELS	11,600
WIND-MOD5	0
WIND-OTHER	8,080
OCEAN	2,500
INTERNATIONAL	500
TECH TRANSFER	1,950
PROGRAM SUPPORT	897
PROGRAM DIRECTION	4,100
RESOURCE ASSESSMENT	700
SOLAR PLANT & CAPITAL EQUIPMENT	2,365
SUBTOTAL SOLAR	72,292
POLICY AND MANAGEMENT	1,527
GEOTHERMAL RESOURCE DEVELOPMENT FUND	72
TOTAL RENEWABLE	91,749
CONSERVATION:	
BUILDINGS & COMMUNITY SYSTEMS	11,900
INDUSTRIAL ENERGY CONSERVATION	15,623
MULTI-SECTOR	19,850
POLICY & MANAGEMENT	1,792
STATE & LOCAL ASSISTANCE PROGRAMS	5,000
TOTAL CONSERVATION	54,165
TOTAL CONSERVATION & RENEWABLE	$145,914

Of the funds requested, $11.9 million are for activities under the purview of this committee; $9.5 million for research and development projects and $2.4 million for program direction. The research and development funds are for three subprograms: Building Systems, Technology and Consumer Products, and Analysis and Technology Transfer.

We are requesting $3.5 million for the Building Systems subprogram in FY 1987 to continue research in walls, roofs, and indoor air quality, infiltration, and ventilation. The wall research will include thermal testing of different types of walls, evaluation of wall thermal anomalies, evaluation of the influence of mass on energy use, and study of foundation designs and earth contact.

Our roof research focuses on improving the energy efficiency and durability of roofs. In FY 1987, research areas will include testing the thermal performance of high and low efficiency roofs under field conditions, developing diagnostic probes for quantitative measurements of moisture in roof systems, and developing a mathematical model to predict thermal performance of composite roofs.

In FY 1987, we will continue our investigations of ways to maintain acceptable air quality in energy efficient buildings. These efforts will include studies of radon entry and mitigation methods and of the generation and distribution of biological aerosols. We will also continue development and evaluation of infiltration, ventilation, and air leakage measurement systems.

We are requesting $5.0 million for the Technology and Consumer Products subprogram in FY 1987. The purpose of this research is to provide technologies needed to develop more efficient building energy conversion processes and equipment. The greatest promise for significant energy savings in building equipment appears to be in the areas of thermally activated heat pumps and advanced lighting.

In thermally activated heat pumps, we will continue research to advance the technologies for engine-driven and absorption systems. In lighting equipment research, we will continue to investigate advanced light sources with emphasis on magnetically loaded lamps and electrodeless gigahertz lamp discharges. We will also continue to study the optimized integration of lighting system components into the total building.

The purposes of the Analysis and Technology Transfer subprogram are to provide the analytic tools and information needed for program planning and to ensure that research results and information on conservation in buildings are transferred to potential users. We are requesting $1.0 million for this subprogram. This funding will support centralized technology transfer activities, continued U.S. participation in International Energy Agency agreements, technology assessments, and policy and program analyses.

We are requesting $2.4 million for Program Direction. This funding will provide salaries, benefits, and travel for a staff of 45 FTE's to manage the Buildings and Community Systems program.

Industry

The FY 1987 budget request for the Industrial Programs is $15,623,000. These funds will be used to carry out work in four subprograms: Waste Energy Reduction, Industrial Process Efficiency, Industrial Cogeneration, and Implementation and Deployment. The goal of these activities is to encourage improved energy efficiency in industry, which accounts for approximataely 37 percent of total U.S. energy consumption. The Department's activities in the industrial area consist of a comprehensive program of carefully targeted technological research and development, combined with technology transfer and other implementation efforts. The R&D activities focus on selected high risk ventures which are not likely to be pursued by the private sector alone and most are carried out by private institutions operating under cost-shared contracts or cooperative agreements with the Department.

The Waste Energy Reduction subprogram supports research and development on improved combustion efficiency through oxygen enrichment, improved burner designs, and sophisticated combustion controls; waste heat recovery by development of industrial heat pumps, high temperature recuperators, and ceramic materials for heat exchangers; and research into waste materials utilization and CO_2 generation and recovery. In FY 1987, $6,300,000 is requested for this subprogram.

The Industrial Process Efficiency subprogram includes laboratory testing of technology to produce steel sheet directly from molten metal; R&D for advanced sensors and control systems; advanced separation systems; and testing of electrode materials for process electrolysis. In FY 1987, $5,479,000 is requested for this subprogram. These new technologies hold great promise to reduce the energy required in basic industrial processes.

The Industrial Cogeneration subprogram focuses on research for coal/water slurry-fired diesel cogeneration systems with high electrical to thermal output and direct conversion of thermal to electrical energy. In FY 1987, $1,500,000 is requested in this area.

The Implementation and Deployment subprogram supports a number of activities for technology transfer. These include targeted workshops, seminars and technical sympusia, and the development of written materials focusing on technologies developed with DOE assistance. Altogether, $500,000 is requested for this subprogram.

These technologies, if successfully brought into production, can provide U.S. industry with important improvements in productivity and help regain technical leadership positions vital to our success in world markets.

Multi-Sector

The Multi-Sector Program includes the Energy-Conversion and Utilization Technologies (ECUT) program, the Energy-Related Inventions Program, and the National Appropriate Technology Assistance Service (NATAS). The FY 1987 budget request for Multi-Sector includes $15.8 million for ECUT,

$3.3 million for the Energy-Related Inventions Program, and $0.75 million for NATAS.

The Energy Conversion and Utilization Technologies research activities are oriented toward basic research and crosscutting R&D problems common to more than one energy consuming sector. They also provide predictive models and design tools useful to the private sector in achieving greater energy productivity. The requested funding will be used to conduct research in six subprogram areas: Combustion and Thermal Sciences, Materials, Biocatalysis, Tribology, International Research Monitoring, and Conservation Program Analysis and Planning.

In FY 1987, $4.8 million is requested for Combustion and Thermal Sciences Subprogram. Combustion research provides analytical and measuring techniques needed to understand the thermochemical and related processes that take place in the combustion of fuels and in the conversion of the released thermal energy to work. The results of this research are used to develop efficient, clean, and reliable combustion systems and devices. Thermal Sciences research develops improved thermodynamic analytical capabilities and experimentally validated computerized data bases. These are needed to provide the technological base used to improve heat transfer processes, reduce heat transfer surface area requirements, and minimize vibration induced by fluid flow through heat exchangers. In FY 1987, research will proceed to develop advanced analysis techniques and to generate a technological data base for the physical sciences of thermodynamics and heat and mass transfer.

The $5.4 million requested for Materials research will be used to investigate and modify the characteristics of high-temperature materials and to further develop the materials-by-design concept. Certain materials such as Long-Range Ordered (LRO) Alloys and Intermetallic Compounds, both of which have highly ordered atomic structures, have great potential for improving the efficiency and performance of high temperature processes, but have not yet been utilized because of their characteristic brittleness. The $2.4 million requested for Biocatalysis research will be used to establish a technological data base for the development of new techniques to manufacture industrial and commercial chemicals using biological systems analogous to conventional processes in chemical engineering. The $2.4 million requested for the Tribology subprogram will be used for research on lubricants, friction and wear to ceramics, and coatings on machine tools that reduce heat and last longer.

Other ECUT funding requested in the FY 1987 budget--$0.8 million-- will be used to assess the status of foreign technologies related to energy conservation and compare it with U.S. technologies, for supporting analyses and for updating the Conservation 5-year plan.

The FY 1987 budget requests $3.3 million for the Energy-Related Inventions Program. This Program was established to evaluate the technical merits of energy-related inventions submitted to DOE and to provide technical assistance and grants to further develop promising inventions. The National Bureau of Standards (NBS) conducts evaluations through its Office of Energy-Related Inventions. Promising inventions identified by NBS are directed to DOE for further assistance to investigate sources of private sector funding or direct support where private sector support is not available. From program inception in 1974 through 1985 approximately 22,000 energy saving inventions had been evaluated by NBS. Based on NBS recommendations, 224 inventions have been awarded grants totalling $16.1 million. Of these, 36 have entered the marketplace generating sales of approximately $110 million and creating more than 900 direct jobs.

In FY 1987, the $3.3 million requested will support the analysis of approximately 1000 proposed inventions, and financial support for approximately 22 of the most promising inventions. During FY 1987, DOE will continue to work one-on-one with inventors to provide business planning assistance, and will conduct workshops which we have tested and found to be very helpful to inventors in dealing with the various and complicated aspects of commercialization.

Appropriate Technology

The Appropriate Technology Program was established to support the development and demonstration of small-scale energy technologies that were matched in scale and nature to local needs. Over 2,000 projects were supported, and almost 900 development projects were completed, to advance the state-of-the-art in Appropriate Technology. In FY 1983, Congress appropriated funds to establish the National Appropriate Technology Assistance Service, to disseminate information on the energy conservation technologies developed through this program and to give expert advice and guidance in using them effectively. NATAS was established in FY 1984, and to date has received over 6,000 requests for information and assistance. The FY 1986 Budget Request contains $0.75 million for NATAS, for the continuation of information and technical assistance to individuals and small businesses.

FY 1987 BUDGET REQUEST FOR STATE AND LOCAL ASSISTANCE PROGRAMS

As a result of the recent Supreme Court decision in the Exxon oil overcharge case, approximately $2.1 billion is being made available to the States and territories for use in five energy grant programs (the four State and Local Assistance Programs in DOE and the Low Income Home Energy Assistance Program in the Department of Health and Human Services). It is DOE's intention that the Court order be implemented as quickly as possible and the funds disbursed in March 1986, in accordance with the formula developed by the Economic Regulatory and Energy Information Administrations. This disbursement, together with the President's FY 1987 budget request, constitutes a near doubling of the appropriated fund levels of the past few years. An additional $750 million is expected to be made available to the States in the settlement of the Stripper Well cases before the end of FY 1986. Therefore no appropriated grant funds will be needed for State and Local Assistance Programs, including the Energy Extension Service.

Our $5 million budget request will cover DOE headquarters and field office salaries and expenses required for administering existing Federal grants and providing technical assistance.

Our goal has been to enable States and local governments to develop and maintain their own energy programs without Federal funds. To that end our efforts have focused increasingly on identifying and establishing private sector sources of funds and developing mutually beneficial working relationships between States and other groups that will help them continue and expand their most successful and highest priority activities.

The transition from activities dominated by Federal grants to State and local government and private sector funding will be completed in FY 1987. In recent years energy partnerships have been developed and opportunities for shared savings and income-generating projects demonstrated and increasingly put into practice. Federal, State, and local governments have made a concerted effort to remove institutional barriers to increased energy efficiency and encouraged use of advanced conservation technologies.

We believe that State capabilities to plan and implement programs and arrange alternative funding sources are now developed to the level at which annual Federal financial aid may be discontinued. The State and local governments are equipped with the training and experience gained in ten years of Federal support.

Our programs, conducted in partnerships with the States and local governments, established a distinguished record of achievement. Together they weatherized 1.5 million homes, upgraded energy use systems in over 42,000 institutions, and established measures to save energy in transportation, lighting, procurement and new and renovated non-Federal buildings.

There is still much to accomplish, and State and local government and private sector programs are increasing the efficient use of energy at all levels of operation as well as in residences, industrial systems, and other consumption sectors. With the influx of funds from oil overcharge cases, increased private sector involvement, innovative funding methods, and advanced conservation techniques, States will be able to continue to increase energy efficiency and the economic benefits that accrue from such accomplishments.

FY 1987 BUDGET REQUEST FOR RENEWABLE ENERGY

The availability of stable and secure sources of energy will continue to play an important role in sustaining a robust domestic economy. The Department's renewable energy programs reflect a continuing national commitment to diversify U.S. sources of energy supply in a manner which fosters free market choices. Renewable energy can be an important part of the nation's energy supply mix and renewable technologies are already making important contributions to national, regional, and local energy requirements. These contributions are possible since the family of renewable energy technologies spans a wide range of resource and technical options at varying stages of maturity. Some technology and resource combinations have been providing substantial energy for many years, others are just beginning to enter the supply system, and some remain in research phases.

Renewable energy technical development overall has been paralleled by an increasing level of confidence in and commitment to these technologies by the private sector. The renewable industry has made significant progress in recent years to its development into the diverse group of many small businesses and sizable divisions of large companies that we see today. There has also been progress with respect to the other institutions concerned with renewable energy supply and use. States have become increasingly involved with promoting renewable energy use, while universities, research institutes, and utilities are promoting awareness and conducting programs to further advance our knowledge of renewable energy potential.

Within the current Federal budget limitations, it is the Department's objective and role to participate in the highest priority research to address the most critical technology base issues. The focus of such efforts will be on those technologies with the greatest long-term promise for contribution to the nation's energy supply mix. These efforts will emphasize precompetitive research critical to advancing technology while avoiding interference with the extraordinary capacity of industry to develop specific commercial products and services. The Department will continue to encourage private sector participation and leadership and will seek input from industry and other institutions in the selection of projects which have the greatest relevance and potential.

The request for FY 1987 of $91.8 million will assist the Department in performing the activities that reflect the nation's commitment to continued development of renewable energy resources, thereby increasing the nation's energy supply options, and, subsequently, national energy security.

I would now like to address the funding requests for selected major programs.

Solar Buildings

Solar buildings technologies have continued to make inroads in housing and, to a lesser degree, in the commercial buildings sector. These technologies can presently supply up to 40% of the energy required to heat individual homes across the United States. There is increasing scientific evidence that such energy contributions could be doubled and extended to additional types of building requirements for energy supply by means of continued opportunity for technological innovations. The FY 1987 Solar Buildings Technology Program budget request of $4.7 million for operating expenses will provide industry with an essential technology base for developing the new materials, components, and technologies required to realize this potential.

Working closely with industry and university laboratories, the Solar Buildings Program is conducting long-term, cross-cutting research which the diverse sectors of the industry cannot support. The goal of these research activities is to increase the energy contribution of solar technologies to the point where 70% to 80% of space heating, hot water, cooling, and lighting requirements of various types of buildings could be supplied at costs that are competitive with conventional fuels.

The FY 1987 program in materials and components includes continued research on new optical and thermal switching films which control solar gain and thermal losses for windows and exterior building surfaces. Research on innovative collectors will increase their thermal efficiencies and reliability, decrease their cost, and expand the application of active solar technologies to cooling systems and other building energy requirements.

New phase change materials incorporated in such conventional building materials as wallboards will make it possible to store and use thermal energy provided by solar energy in all parts of the building. Advanced thermal transport concepts will enable energy to be transferred from the point of collection at the building exterior to any interior location, thereby improving the energy performance of solar building systems.

Systems research activities encompass both residential and nonresidential building applications. Research on open cycle solar absorption and solar desiccant cooling technologies will be aimed at increasing their energy efficiencies, the key to achieving viable solar cooling applications. An important element of the FY 1987 systems research program is the development of analytical tools to allow architects and engineers to predict system performance. Researchers will also continue to monitor, analyze, and evaluate the performance and reliability of solar building technology. Analysis techniques are being developed for integrating these solar technologies with conventional heating and cooling systems.

Photovoltaics

Photovoltaics (PV) is on its way to becoming a significant energy supply option. The partnership between DOE and industry has resulted to date in rising conversion efficiencies, increasing reliability, and lower costs, all of which have helped the technology to establish a strong foothold in the competitive energy market, with a broad range of viable applications. In FY 1987 the Photovoltaic Program, with a budget request of $19.6 million for operating expenses and $1.0 million for capital expenses, will seek to advance the basic understanding of technical issues associated with materials formation and physical phenomena of the PV cell.

Amorphous silicon is an attractive thin-film photovoltaic material which could establish PV technology as a broadly competitive electric power production option. U.S. research leads worldwide efforts in addressing the issues leading to the optimization of single junction submodules and the investigation of higher efficiency multijunction concepts. The efforts will lay the ground work for a viable industrial effort capable of achieving 10 percent efficiency single junction and 13 percent multiple junction large area submodules.

Polycrystalline thin films also represent promising candidates for meeting the major programmatic criteria relating to cell efficiency, material processing requirements, and performance stability. Progress has been made in the development of low cost deposition methods, and in cell efficiency. FY 1987 efforts will concentrate on defining the scientific and technological barriers to approaching theoretical efficiency and on the development of large area film fabrication concepts for the most promising of these materials.

As a result of DOE's program, single-crystal gallium arsenide and single-crystal silicon solar cells currently hold records for the most efficient photovoltaic conversion of sunlight to electricity. But the efficiency of such materials is inherently limited because not all incident sunlight can be utilized due to the frequency selectivity of the specific materials involved. To overcome this difficulty, researchers are exploring concepts that will include seeking improvements in selected single-junction cells as well as studying concepts to mechanically or optically couple cells or to fabricate, as one structure, two or more cells of different materials. The goal of this high priority effort in high efficiency concepts is to achieve 35% efficient small area cells for use by industry as part of its development effort.

The FY 1987 program will also maintain its unique capability for precise measurement of material and cell parameters. This work at SERI guides researchers throughout the U.S. in understanding and correlating observed physical phenomena. The program will also support other fundamental research in quarternary and ternary compounds, and promote basic material work at universities. Finally, the wealth of information gathered by the program from materials to systems during its ten years of research and development will be used to assist industry in its efforts to bring photovoltaic technology to competitive maturity, domestically and internationally.

Solar Thermal Technology

The technology base for solar thermal technology has dramatically improved as a result of significant achievements within the last two years. These achievements include substantial system cost reductions and performance enhancement due to the research in advanced solar thermal components and subsystems which resulted, in part, from DOE's cooperative efforts with industry. At present, solar thermal technologies are capable of delivering electricity at 13¢/kWhe. However, solar thermal technology must be capable of 5¢/kWhe for electric power production and $9/MBtu for thermal energy in order to be competitive with a mix of other energy generating technologies. The FY 1987 program, with a budget request of $15.3 million for operating expenses, emphasizes activities which address the component and subsystem improvements/advances necessary to approach these objectives. Heliostat sizes have increased three- to four-fold, while costs have been reduced by 40% since Solar One (Barstow) became operational in 1982. The stretched membrane concept has the potential to further reduce the heliostat field and parabolic dish concentrator costs by another 50%. The FY 1987 research will continue the design and testing of these advanced concepts.

Central receivers using molten salt or sodium as heat transfer fluids would allow reductions in the size of advanced receivers and enable the development of low pressure receivers that are lighter in weight with

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lighter support structures. The new fluids can also be stored at high temperature and low pressure for plant operation during long hours of reduced insolation. Research efforts in this area to-date have established the basis for reduced receiver and storage costs by 50%, improving both the overall plant cost and levelized energy costs of solar thermal systems. The development and testing of these advanced subsystems will continue through FY 1987. The Vanguard dish module has proven the high conversion efficiency of sunlight to electricity by achieving a 29% net (31% gross) system efficiency using a kinematic Stirling engine. Development of the free-piston Stirling engine concept, in cooperation with NASA, will continue in FY 1987. This engine has the potential to achieve the long-term goals of high reliability and performance at competitive cost. Additional research projects which are underway and will continue in FY 1987 include the development of a thermochemical cell in which spent chemicals would be regenerated by solar energy to produce electricity. Additionally, several present methods for producing solar thermal electricity generating systems are limited to operation below 750°F due to excessive thermal losses. Researchers will continue to study approaches for replacing the sensible heat transport methods with thermochemical energy transport and storage processes which have the potential to dramatically reduce thermodynamic losses and thereby increase overall efficiency. Experiments addressing the technical feasibility of thermochemical transport will also be undertaken.

Biofuels

Biofuels energy technologies utilize a variety of organic feedstocks, such as terrestrial and aquatic crops and municipal waste, which can be converted by thermochemical and biochemical processes into high-value gaseous, liquid, and solid fuels. Biofuels currently are supplying approximately 2.7 quads or almost 4% to the U.S. energy supply. Development of advanced biofuels technologies offers the potential for significant additional contributions over the longer term. The FY 1987 budget request for Biofuels Energy Systems is $11.6 million for operating expenses and $0.6 million for capital equipment. During FY 1987, the Biofuels Program will focus on key long-range research and development issues to provide a technology base for private sector development of biofuels production and conversion technologies.

Feedstock production research supported within the Budget Request in short-rotation intensive culture will include genetic selection to improve biomass yields, along with examination of monoculture plantings to determine operational yields and susceptibility to disease and pests. Research on herbaceous energy crops will focus on screening of promising species which can be grown on marginal croplands, as well as small-scale experimental plots. Aquatic species research will include species screening, genetic research, and small-scale experiments to improve the productivity of microalgal species and the efficiency of conversion processes.

Thermochemical conversion research will focus on liquefaction and pyrolysis of biomass feedstocks to produce high-value liquid and gaseous fuels. Municipal solid waste research will continue to address the production of liquid and gaseous fuels via thermal liquefaction and gasification. Combustion kinetics and emissions research will also be conducted.

Research in biochemical conversion will focus on improving processes for conversion of organic materials to alcohol fuels in order to advance the technology for competitive production of octane enhancers and additives for transportation fuels. Research in the anaerobic digestion of municipal waste will address the improvement of microorganisms, as well as attempt to understand the biochemistry and physiology of the anaerobic digestion process.

Wind Energy

Updated information, recently received, indicates that there are presently over 13,000 wind turbines operating in the U.S. with an installed capacity greater than 1100 MW. However, many areas remain where continued research efforts are needed to establish the knowledge base necessary for industrial development of viable wind technology within the context of evolving competitive and unsubsidized electric energy supply markets. It is the objective of the Wind Energy Research Program to improve the understanding of fundamental atmospheric fluid flows and their effects on wind turbines and to translate this understanding into tools that industry can use to design and develop improved, more reliable, cost competitive wind turbines. The FY 1987 budget request of $8.1 million for operating expenses and $.2 million for capital equipment will fund the research required to accomplish these objectives.

Commercial development which started at the 50 kw size has now moved into the 100-200 kw range. With the success of those tests and the current successful operation of the larger Mod-2 experiments, sufficient data is now available to industry to proceed with larger systems. The large experimental Mod-2 and Mod-5 projects will be closed in FY 1987 to concentrate resources on fundamental structural and aerodynamic research to benefit all system sizes.

Major improvements in turbine energy capture are believed to be achievable through aerodynamics research activities. Tests on specially instrumented commercial machines will continue in order to collect actual operating data in a wide range of environments. This will improve the understanding of the performance of different turbines' energy capture as it is affected by turbulence, wakes, and micro-siting and will further the development of air foils tailored to wind turbine requirements.

FY 1987 structural dynamics research activities will improve the understanding of how aerodynamic loads induce structural stresses and rotor and tower material fatigue. Research efforts are aimed at the development of predictive models which take into account the complex interactions of forces on wind machines. Cooperative field assessment activities with industry are used in this area to acquire the data necessary to verify theories.

Advanced component development involves the application of basic science and research on aero and structural dynamics to develop components that could lead to major improvements in the energy production of advanced wind turbines. This area also includes studies on environmental effects of wind turbines, application of wind turbines as fuel savers with diesel generators for remote power generation, and on the interaction of wind machines with existing utility power systems.

Ocean Energy

The Ocean Program conducts the research and development of ocean energy technology to a point where the private sector can make competent assessments of whether applications of the technology are viable energy supply alternatives. This will be accomplished through appropriate research on components and systems modelling. The OTEC program is guided by a long-range goal to investigate the technologies which could reduce the capital cost of the OTEC systems to $3200/kWe (1984 dollars). The program strategy focuses on reducing the technical uncertainties associated with a 5-15 MWe, near-shore OTEC system which serves as an approximation of the incremental capacity requirements of the type of markets representing the likely point of initial competitiveness for this technology. The FY 1987 budget request is $2.5 million for operating expenses.

The emphasis of the FY 1987 Ocean Program will be placed on experimental verification and testing and thermodynamic research and analysis. Material and structures research and oceanographic, environmental, and geotechnical research previously undertaken have provided a data base that is useful for the two FY 1987 research areas, but do not currently require the degree of emphasis that was necessary in past years.

The objective of the experimental verification and testing program is to provide a facility for private industry to conduct seawater tests and experiments which verify OTEC component functional feasibility, performance, and operational characteristics on a scale which can be extrapolated for use in modular systems applicable to small plants. The FY 1987 budget will also provide funds to upgrade the Seacoast Test Facility by expanding the capacity of its seawater systems for open-cycle OTEC experiments.

One objective of the thermodynamic research and analysis program is to experimentally determine the effects of seawater and non-condensible gas on open-cycle heat and mass transfer processes. The program will also validate selected power system analytical models at a scale sufficient to extrapolate a generic understanding of how to design potentially cost- effective open and latent-heat power systems which could meet the cost goals of the program. Reaching this goal is dependent upon increasing the output of the power system and significantly reducing the life cycle cost.

Other Solar Activities

The FY 1987 budget request for the efforts in support of planned research activities is $8.1 million for operating expenses and $.6 million for capital equipment. These efforts include international, technology transfer, and resource assessment programs, the Solar Energy Research Institute, and program support and direction.

Technology transfer activities such as publications summarizing research results across individual investigations and performing centers are important mechanisms for transferring information to the R&D community in context and provide the basis for facilitating information exchange and dialogue. Additionally, continuing requests are received for information from a more general cross section of the public and the energy community concerning renewable energy. The FY 1987 budget request of $1.9 million for operating expenses and $.1 million for capital equipment will continue the technical and public information services at levels commensurate with solar research and development activities.

The international solar energy program provides Federal organizations and industry with a vehicle for cooperative international trade development for renewable energy. DOE is responsible for chairing an interagency committee, the Committee on Renewable Energy Commerce and Trade (CORECT) which provides a forum where industry and public entities can coordinate the use of existing resources and authorities to exploit export opportunities for the domestic solar energy industry. Additionally, funds are used to conduct a program managed by the Department of Commerce which cost shares, with industry, the development and presentation of exhibitions, special trade missions and trade development services with a continuing focus on international markets of more significant potential. The FY 1987 budget request is $.5 million for operating expenses.

The FY 1987 budget request of $.5 million for the Solar Energy Research Institute will fund capital improvements to the permanent DOE facilities that will improve efficiency, safety and security.

Solar resource assessment activities will provide information regarding the distribution and spectral and temporal variability of solar energy resources throughout the United States. The FY 1987 budget request for these activities is $.7 million. Coordination of these activities and other ongoing research and development activities is an important part of the program support and direction functions. FY 1987 requests of $.9 million for program support and $4.1 million for program direction funds will, among other things, provide technical and crosscutting studies of the various solar technologies, provide for updates to multi-year program plans, continue technical and programmatic dialogue with industry, and manage the diverse research activities in the national solar research program.

Geothermal Energy

The Geothermal Energy Program carries out research and development, in cooperation with industry, on an array of geothermal resource types (including geopressured, hydrothermal, hot dry rock, and magma) and conversion technologies designed to define the technical and economic boundaries of this vast domestic energy supply resource. Program activities include applied research, technology development, and information efforts which provide the basis for the timely introduction of new concepts and products into the marketplace by the private sector. The FY 1987 budget request for the Geothermal Program is $17.9 million for operating expenses.

The purpose of the geopressured research program is to define the technical characteristics and recoverability of this large resource of hot brine and methane which lies primarily beneath the U.S. Gulf Coast. The FY 1987 program includes experimental well flow testing, tests of the conversion of the combined energy content (thermal and chemical) to electricity, and supporting research on the dynamic response of geopressured reservoirs to production conditions, chemical constituents of the brine, and the possibility of land subsidence.

Hydrothermal research will allow the expansion of the accessible resource base through an improved understanding of the processes for extraction and reinjection of geothermal fluids; new materials capable of withstanding high temperatures, high pressures, and highly corrosive environments; brine chemistry research leading to techniques to prevent plugging of wells and pipes; advanced power cycle technologies; field testing techniques for appraising very high temperature geothermal resevoirs at the Salton Sea Scientific Drilling Project; and the experimental study of survey methods applicable to young and andesitic volcanoes.

Hard rock penetration research will be performed jointly with industry to improve the technology and reduce the uncertainty of geothermal well drilling, which currently represents about half of the cost of geothermal power and exceeds the cost of typical petroleum wells by factors of two to four due to the fact that geothermal wells are generally deeper, and encounter harder rock, higher temperatures, and more corrosive fluids than do oil and gas wells. Experimental programs include high-pressure water jets combined with rock cutters, mechanics of rock penetration, and drilling fluid loss control.

Research will also be carried out to determine the depth and size of a large continental magma chamber, to evaluate alternative methods of energy conversion, and to develop materials and instrumentation capable of operations in the 1000 degree Celsius magma environment.

Hot dry rock research involves the evaluation of the properties of deep crystalline rock and the development of methods to extract geothermal heat from such resources. In FY 1987, the experimental extraction of heat from the large fractured reservoir at Fenton Hill, New Mexico, will begin and research on improved diagnostic technologies including microseismic measurements will be extended to higher temperatures.

Geothermal Resources Development Fund

The Geothermal Resources Development Fund was established to broaden the geothermal energy technology base by guaranteeing loans for private sector development of several state-of-the-art facilities. The FY 1987 request is $72,000, which allows for evaluating projects, restructuring existing guarantee agreements, and monitoring outstanding loans.

CONCLUSION

Mr. Chairman, I believe that the budget that I have summarized will contribute to increased energy supply diversity and end-use efficiency and should serve to promote increased competition in the marketplace. I believe that this budget request will allow us to address the items of highest priority in research and development in the fields of energy conservation and renewable energy and thereby contribute to the accomplishment of our national goal of fostering an adequate supply of energy at reasonable cost. This is a budget which I believe seriously recognizes today's fiscal responsibilities, as well as tomorrow's anticipated needs.

Mr. **Fuqua**. Thank you very much, Madam Secretary.

I think Mr. Hall has a statement that he would like to make.

Mr. **Hall**. Yes, Mr. Chairman and members of the committee. I want to thank you not only for convening this series of hearings to review the 1987 budget request of the DOE in the areas of fossil conservation, renewables, and other basic energy research programs, but also for allowing me to put my statement into the record at this time.

The work that this Department does in these areas has been and continues to remain, as the speaker has just very ably set forth, very important to the national interests. As you know, Mr. Chairman, I and other members have had some concern for some time over the Crossviten solar power project being conducted by Texas Tech University in Lubbock. My concern—it's not in my district, but it's in the district of Mr. Stenholm and Congressman Combest—and my concern, as well as their concern and other members of the committee from Texas has centered primarily on whether the project, which is a solar bowl concept, will be evaluated by the Department on a basis consistent with the other solar thermal technologies. That's all we're asking.

We're currently having some discussions with the Department on the future of this project, and I say this, that DOE has been very considerate and it has been operated and manned by people that I certainly have been able to support and to work with. And it appears that we're on the way to making some progress on reaching some type of reasonable resolution of the issue that is outstanding at this time.

Further discussion, Mr. Chairman, needs to take place, though, between the Department and those who are operating the project, and I hope that these discussions will be concluded to everyone's satisfaction in the next few weeks. Therefore, I won't take the committee's time with questions related solely to this project now, but at the appropriate time I'd like to make a unanimous consent request that the Department appear before the committee at the markup on March 19 and to give us some report on the outcome of those discussions that we understand are going to take place.

And with that, Mr. Chairman, I thank you and I yield back the balance of my time.

Mr. **Fuqua**. Thank you.

While we're awaiting the response to DOE's request for deferrals that have been sent up, what position has your responsibility taken toward the ongoing and negotiable contracts which may be involved in some of the deferrals?

Ms. **Fitzpatrick**. Mr. Chairman, I'd be the first to admit that we're in a difficult situation. We are very hesitant to damage program progress; at the same time, we have a legal notice that there is a deferral that has been proposed to the Congress. And we have to be very careful about what money gets spent and what money remains still available for the disposition of the Congress.

Mr. **Fuqua**. Congress hasn't disposed of that——

Ms. **Fitzpatrick**. It has to be available for your disposition. We could foreclose your option, in a sense, by spending the money, and we don't want to do that.

So we are almost on a case-by-case basis trying to maintain both program integrity and our legal responsibilities.

Mr. **Fuqua**. Well, suppose that Congress does not follow through with every one of the deferrals; some they may, some they may not. Is the 1987 money going to be spent on the same projects that it was intended to for 1986?

Ms. **Fitzpatrick**. In some cases, it would not be. No, the President's budget request assumes that the money which is deferred from 1986 would be applied to the programs as outlined in the 1987 budget request. It would be a setoff against the need for new budget authority.

Mr. **Fuqua**. But—maybe I didn't understand that answer that well. As I understand it, in some cases it would not be——

Ms. **Fitzpatrick**. Yes; in fact, generally, it would not be.

Mr. **Fuqua**. Even if Congress had decided not to concur with the deferral?

Ms. **Fitzpatrick**. Oh, I'm sorry; I thought your premise was if Congress allowed the deferral.

Mr. **Fuqua**. Oh, no. Well, I said that in some cases, Congress would allow the deferral.

Ms. **Fitzpatrick**. I see.

Mr. **Fuqua**. But in cases where the deferral was not allowed, then would it be your intent to spend the 1987 money as it was intended for 1986? Continue that program?

Ms. **Fitzpatrick**. Yes, sir; if Congress does not allow the deferral, then we would intend to spend the 1986 moneys as appropriated.

Mr. **Fuqua**. I mentioned the cooperative R&D venture and I think it's a worthy objective. When do you think that information will be available, both to the committee and to industry, of more specificity of what this will entail?

Ms. **Fitzpatrick**. We are working now in the Department, Mr. Chairman, on more specifics of what a capital cooperative R&D venture would look like. There are certain legal and administrative decisions that will have to be made. And we would hope, well before the end of this fiscal year, to be able to inform the Congress more fully and to tell industry what it is that we have in mind in order to ascertain their interest. Obviously, this is a program which is fully dependent on the willing participation of industry; it is not the case, as with our usual R&D where we let a contract and normally have several bidders who are quite anxious to do anything as long as we cover all their costs. The point of this entire project would be to increase the amount of industry cost sharing and to let industry have a greater opportunity, perhaps, to direct what R&D should be done. This means that they have to be willing and eager partners. We have had some indication from industry in certain areas that they want very much to talk about it; exactly what will come of it, of course, at this point we can't say, which is why no specific amount of money has been allocated to it in our budget request. We would inform the Congress of what our plans are as they develop and let you know what it is that the R&D ventures will look like and who's interested, and eventually, how much money would be needed for our share of it.

Mr. **Fuqua**. And so how soon do you think that will be available?

Ms. **Fitzpatrick**. I would expect to have more specificity within a few months, and I would hope to be able to go to industry before the end of this fiscal year.

Mr. **Fuqua**. It will take that long?

Ms. **Fitzpatrick**. Yes; we have come up with some legal and administrative questions relating to such things as antitrust which are going to need a little bit of time to work out.

Mr. **Fuqua**. Antitrust in joint R&D ventures?

Ms. **Fitzpatrick**. Yes, sir; because one of the provisions in our proposed format would be that we would be looking for several members of industry to join in a kind of consortium. And those would be people who ordinarily would be competitors, and therefore we have to comply with antitrust.

Mr. **Fuqua**. Would they be exempt under the Joint R&D Venture Act that is law now?

Ms. **Fitzpatrick**. Yes; they probably would be covered under that so that they would get the slightly more lenient treatment. They still have to meet antitrust requirements, but at least they are not considered per se in violation of it anymore.

Mr. **Fuqua**. With the budget constraints that we're faced with now, would it be beneficial to combine some of the programs, such as the solar and conservation and building programs?

Ms. **Fitzpatrick**. That's something we can consider, Mr. Chairman. We have noted in the past that there was some overlap between those programs, the major point of overlap being in work on windows. And all of that work has now been concentrated on the solar side. The Conservation Buildings Program concentrates on electrical lighting systems and heating and air-conditioning systems, principally in heat pumps. The Solar Buildings Program is working, as I said, on windows, and also on passive solar design and materials concepts.

So we think we have eliminated the overlap between them. Further consolidation might achieve some efficiencies; it also might simply add to some confusions. But we would certainly be happy to discuss that with the committee.

Mr. **Fuqua**. A project that the committee has been very interested in over the years is the solar 1 project in Barstow, CA, and I understand that contract expires in August of this year—of 1987, pardon me. What are your plans for it, and also for the solar tower at Sandia?

Ms. **Fitzpatrick**. Mr. Chairman, that solar 1 project is an amazing technology, and the installation there is working very well. It has a high availability rate; almost every month it surpasses its previous month's electrical generation, and it is certainly a successful system.

What we have learned from it principally is that we can do even better. We can build better collectors; we can build a better central receiver. I understand that some of the technology, and especially the control and systems technology that was worked out for it, has already been picked up by the utility industry.

What to do with that particular site and that equipment is still an open question which we are working on with several of the utilities, especially in the Southwest, who are very interested in it. And we have accepted their proposals to develop their suggestions on what should be done. We would coordinate, of course, everything in the solar thermal program between those two major installations, the one at Barstow and the one in Albuquerque.

Mr. **Fuqua**. Thank you.

Mr. Slaughter.

Mr. **Slaughter**. No questions, Mr. Chairman.

Mr. **Fuqua**. Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman.

The question that comes to my mind is a procedural question relative to the budgeting process under Gramm-Rudman. If the sequestration process is what ultimately is implemented, do you foresee where you would be required to, across the board, make cuts within these various programs that you've alluded to? Or would you have the ability to prioritize the various experimental projects that you've addressed in your prepared statement?

Ms. **Fitzpatrick**. I am frankly not sure, Mr. Packard, exactly what level the percentages would be applied at, whether we are required by Gramm-Rudman to apply it at a line item level or an overall appropriation level, for the interior appropriation and the energy and water appropriation, which are the two that cover these programs. And I would like to look into that and get back to you for the record, if I may.

[The material follows:]

GRAMM-RUDMAN HOLLINGS SEQUESTRATION

The sequestration of funds applied to all new budget authority appropriated for fiscal year 1986. The reductions were uniformly applied to all programs, projects, and activities in conformance with guidance from the Committees on Appropriations of the House of Representatives and the Senate so that no work was terminated as a result of the application of Gramm-Rudman-Hollings. Subsequent to determinations for fiscal year 1987 sequestrations, it will again be necessary for the Committees on Appropriations to determine the level at which any reductions will be applied.

Mr. **Packard**. It would be of interest to me because, obviously, your budgeting process under the President's proposal has been to try to put the money where the projects seemed to produce the greatest potential.

Ms. **Fitzpatrick**. That is true, Mr. Packard.

Mr. **Packard**. And I think that's, of course, a wise thing to do. But let me pursue that question just a little bit further.

In trying to evaluate the various research projects that we have, the photovoltaic, the geothermal, the windmills—many of these which I've been able to visit in the last 2 years—some have hope for commercial use; others simply don't. Good experimental work, but doesn't have a great deal of potential to produce energy in a cost-effective way. Have the dollars been assigned in this stringent budget—1987 budget year under the present proposal—have they been assigned to the potential of commercialization, or to the interest in terms of the experimental work?

Ms. **Fitzpatrick**. That's a very good question, Mr. Packard; and what it really addresses is the fact that research is, in some ways, a kind of an aesthetic pursuit. Things can be very intriguing and interesting to pursue, and you wonder whether anything will really come of it.

If I may, I think I can help you best by reviewing for a moment what our R&D planning process is, how we go about deciding what our priorities are.

We began about 3 years ago a serious effort to assess what are the renewable energy supply options that are available to the United States. What sources of energy do we have available here? Where are they located? And what would it take to bring them to commercial use? This varies from region to region in the country, obviously.

We established a means of determining what we call an energy contribution potential, and we went through hundreds of options of how to go from sunlight, for example, to electricity; or sunlight to a gaseous fuel; or sunlight to a solid fuel or liquid fuel. Also, how do you take various biomass products—grasses, wood, algae, for example—and turn them into usable energy? Do we want to produce electricity? Do we want to produce fuels for industrial use? Fuels for building heating? Fuels for transportation?

So we have a whole panoply of supply options and a whole panoply of use options. And worked out over the matrix of regional needs and supply opportunities, what are the best priorities and the options of greatest potential for supplying what our needs are going to be?

Then we try to determine what are the technical steps that must be taken in order to get from potential to actual commercial—economically and technically viable—options. And then, within those steps which must be taken, which ones are proper for the Federal Government to pursue, and which ones are really engineering and product development responsibilities that are properly in the private sector?

Having done all that, we then determine what the priorities are, what are the most important supply options—that is, that hold the greatest potential for contributing to the Nation's energy needs—that are matched with the kinds of fuel and resource supplies that the Nation actually has, region by region, and which have critical technical steps which are properly addressed by Federal Government R&D.

And with all that, we arrive at our priorities in each program area. And we play programs off against each other, of course. Some programs, such as photovoltaics, we consider to be a very viable and high priority option because sunlight is available virtually everywhere. We have made great strides in photovoltaic materials and systems. We can see that it is rather rapidly approaching commercial viability, and it is producing a kind of energy—electricity—in a form that the Nation needs more and more.

So that's the kind of a rationale that we follow, and I hope that it answers your question.

Mr. Packard. Thank you.

Do you have figures or percentages to—I was simply interested in how much of the short dollars that we're going to have in the 1987 budget are going toward maintaining a completed research project? For instance, the geothermal plant south of El Centro is essentially completed. How much of our Federal dollars are going toward maintaining those projects versus new research or additional basic research programs?

Ms. Fitzpatrick. That particular plant does not have any funding request in 1987. We are really finished with that.

There have been a number of major projects, largely capital equipment projects that we have been supporting in the last few years, that have really come to their natural conclusion. We are trying to maintain program momentum in the high priority areas. We have minimized or almost eliminated new starts, but we are not, for the most part, continuing to support because they really don't need it, some of those rather expensive projects, capital projects.

Mr. Packard. If time would permit, maybe you could just respond to it in writing.

Ms. Fitzpatrick. Yes.

[The material follows:]

RENEWABLE HARDWARE PROJECTS

The Department has either completed or is in the process of bringing engineering development projects to an orderly conclusion which were initiated in earlier years. These projects will come to a natural conclusion at which time they will either be shut down and the "lessons learned" archived for later use by the private sector, or they will be transitioned to the private sector, or they will be transitioned to the private sector for continued operation.

It is not Departmental policy to continue using Federal dollars to maintain these projects once they have completed their essential research objectives. Listed below are the renewable energy projects involving significant hardware or facilities for which Departmental reponsibility has not been fully completed.

[Dollars in millions]

Project	FY86	FY87
Barstow Central Receiver	$2.3	$1.4
Small Community Project	.2	.2
Herber Binary Plant	0	0
Fenton Hill Hot Dry Rock Project	7.2	5.0
Geopressured Design Well Operations	3.2	3.0
Biofuels Gassifier	5.0	0
Mod 2 Wind Machine	1.0	0
Mod 5 Wind Machine	1.3	0
Total	20.2	9.6

Mr. Packard. I'd be interested in knowing what kind of funding we're having for clean coal research. We funded a half a billion dollars last year—or rather, authorized a half a billion dollars. I'd be interested to know just what kind of work we're doing in that area.

Ms. Fitzpatrick. Yes, sir.

Mr. Packard. Thank you very much, Mr. Chairman.

Mr. Fuqua. Mr. Sensenbrenner.

Mr. Sensenbrenner. Thank you very much, Mr. Chairman.

The December 1985 ERAB solar panel report noted, "The biofuels program is relatively disorganized. The number of laboratories involved in management functions should be reduced, the roles of the various research laboratories clarified in the research focus."

What is the Department planning on doing to implement this recommendation, and what is the schedule for implementation?

Ms. **Fitzpatrick**. Mr. Sensenbrenner, I generally agree that there does need to be some work done with the biomass program. We reorganized it in August 1985. We are working on focusing its activities. In particular, it needs to be brought more in line with the way we run our other programs, which is to have one or two lead centers in the laboratories where we can attain a kind of critical mass of knowledge about the technologies. So I think that the ERAB's points are well taken, and we are working on trying to improve the management.

Mr. **Sensenbrenner**. When is it going to be done?

Ms. **Fitzpatrick**. It's going to be done this year.

Mr. **Sensenbrenner**. Will you have any specifics on how this is to be done? Because I notice that the request for biomass has gone from $27 million appropriated for fiscal 1986 to $12.2 million for fiscal 1987, and it seems to me that in the times of fiscal crisis that we're facing now, we can't afford to have any mismanagement whatever.

Should the Congress approve the reduced authorization level, are these savings going to be accomplished in better management or are we going to meat-ax all of the programs simply because we can't get around to better management?

Ms. **Fitzpatrick**. We are not going to sacrifice the programs to inept management, Mr. Sensenbrenner. We are going to focus the programs on what are the highest priorities that we can afford to support.

[The material follows:]

BIOFUELS

Departmental management is aware of the ERAB Solar Panel Report and has its recommendations under advisement. I can assure you that we strive to improve our management structure and program efficiency on a continuing basis in order to achieve a maximum return on our research investment. The difference between proposed levels of funding for fiscal year 1986 and fiscal year 1987 is not a result of management savings but reflects the reductions necessary to accomplish governmentwide deficit reductions while focussing outlays on highest technical priorities most suited to the Federal role.

The DOE fiscal year 1987 budget request of $12,200,000 is directed at the highest technology priorities and remains balanced between research directed at improving the characteristics of feedstocks, and research directed at defining the process dynamics associated with the priority biochemical or thermochemical methods for producing fuels from these feedstocks. For each combination of feedstock and conversion technology, specific research objectives have been established and provide the basis for evaluating progress and determining tradeoffs among technical priorities. In general, successful accomplishment of these objectives would lead to viable gaseous fuels from the woody and herbaceous feedstocks within the mid-term, alcohol fuels from woody biamass in the longer term, and petroleum-like fuels from microalgae in the very long term.

Mr. **Sensenbrenner**. Well, I would appreciate some written information, specifically on how much of the $15 million savings that is contained in the President's budget request will be saved from improved management techniques and the implementation of the ERAB report. Frankly, just looking at some numbers on a piece of paper, given the criticism that has developed around biomass, we might have to have some authorization language to get the train out of the station on this one.

Thank you very much, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Sensenbrenner.

Mrs. Schneider.

Mrs. **Schneider**. Thank you, Mr. Chairman.

Welcome, Ms Fitzpatrick. I would like to ask you some questions that take into perspective a little bit of the historic view of where energy conservation has been.

In 1984, the Federal energy subsidies totalled somewhere between $40 billion and $50 billion, and energy efficiency improvements were responsible for about 20 percent of our entire energy services or energy mix. Yet, energy efficiency received less than $800 million out of that total $40 billion to $50 billion energy subsidy budget. In other words, it's less than 2 percent.

Now, I think that we have seen through the years the cost-effectiveness of investments in energy efficiency; yet this year, the 1987 budget calls for an expenditure of only $75 million out of $40 billion in Federal subsidies, and I wonder if you could please explain the discrepancies between the opportunities and the very meager Federal efforts that seem to be put in this direction, particularly since the Secretary of Energy had indicated that he was interested in looking at winners and losers, and those would receive the reward of appropriate funding. It appears that energy efficiency is one of the winners, just based on cold, hard, numbers; and yet, that's not being reflected in energy priorities in the 1987 budget.

Ms. **Fitzpatrick**. Mrs. Schneider, I think you're absolutely right, that energy efficiency is a proven winner. People quibble a little bit about how much we have impproved in efficiency over the last 10 years, but there's no argument that it has been very substantial. Our figures that we usually use say that we would be using about 14 quads more energy now if we had continued at 1973 trends and practices. That's 14 quads in addition to about the 75 quads that we do use. So with 20 percent increases in efficiency, it's certainly well in line with the facts.

In a sense, that can tend to play against Federal subsidies because we are seeing more and more a shift in choices by the private sector, especially as they make long-term choices, say, in industry, to choose new equipment, boilers, things that they're going to need for 20 to 30 years. They are certainly choosing energy efficiency, and they are certainly choosing fuel flexibility in getting away from petroleum.

I agree that there are still very substantial gains that can be made through research. We still have opportunities for technological improvements, especially in areas such as sensors and controls and high-temperature materials and new kinds of heat transfer and thermal cycle technologies. But I think that our private sector choices are really reflected by where the Federal Government puts the money. The Federal Government's goal is to provide those choices, to provide the technological base that will allow industry to produce the products that gives the private sector the choices——

Mrs. **Schneider**. Equity in choices.

Ms. **Fitzpatrick**. That's right.

Mrs. **Schneider**. And when we're talking about a meager 2 percent return on the investment dollar, it doesn't seem too equitable. But let me get on to my next question, which has to do with our international competitiveness.

The President's Commission on Industrial Competitiveness said last year that our country has lost 7 out of 10 of the high technology markets in recent years, and these are the markets that include some of the high efficiency products that you're talking about—the motors, the lighting systems, the heat exchangers, a variety of manufacturing processes, technologies, vehicles, that sort of thing. Is there any concern or is there any one person out of the platoon of people that work at DOE that is concerned about where our country is going in terms of our R&D investments and the import markets, the export markets?

Ms. **Fitzpatrick**. I think that there are a lot of people who are concerned, beginning with the Secretary. And we have taken some steps in the last couple of years to pay particular attention to that. For example, Congress authorized—and we have vigorously pursued—an interagency export council, which we call the Committee on Renewable Energy, Commerce, and Trade, which addresses the particular problem that the renewable energy industry has in our country. We have, I think, the best technology available in the world; but because——

Mrs. **Schneider**. No, I'm sorry, we rank fifth. We are behind insofar as energy technology is concerned; we rank fifth behind our industrial competitors of Japan, West Germany, France, and England.

Ms. **Fitzpatrick**. Are you talking about export levels or about the quality of our technology?

Mrs. **Schneider**. In quality.

Ms. **Fitzpatrick**. In quality?

Mrs. **Schneider**. In quality, yes.

Ms. **Fitzpatrick**. Well, I think I'd like to talk to you about that. Maybe I need some information that you have.

Mrs. **Schneider**. Very fine. I'd be happy to share it with you. Thank you for your testimony.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mrs. Schneider.

Mr. Hall.

Mr. **Hall**. Mr. Chairman, I think probably in the interests of time from my standpoint, that probably this is an appropriate time for me just to ask a unanimous consent request that the Department do appear before the committee on March 19 and give us a report on the outcome of the discussions that we're going to be entering into with you between now and that time.

Mr. **Fuqua**. Let me say that rather than that request, we'll work with the Department and try to have the information by that time——

Mr. **Hall**. All right. Thank you, Mr. Chairman.

Mr. **Fuqua**. Back to the gentleman.

Mr. Walgren.

Mr. **Walgren**. Thank you, Mr. Chairman.

Although we're focusing on some of the renewable elements here, as I understand it this is the only time that I might get an opportunity to ask you about the intentions of the Department with respect to the steel initiative, which is also in the conservation budget.

The other day, when Secretary Harrington was before the committee, he said they intended to defer the $7.5 million or so that was appropriated or authorized in the 1986 budget for this; and yet, that deferral has not yet come to the Congress. I would like to urge you not to defer at this point, and would want to stress to you the importance of this kind of initiative in basic research for the steel industry. From my point of view, it is very clear that the industries that we've invested heavily in as a Government—agriculture and aerospace in particular, where we are in with both feet—do very well internationally, and those where we have a real investment deficit are having terrible problems. And in the steel industry, we are literally being had for lunch by the foreign competitors that we face.

Now, I appreciate the argument that there is a private sector role in all this. Last year, Mr. Streb indicated that this was not an appropriate Government function. Now, I would like to ask whether or not you are going to defer. Obviously, this is a gray area; there are strong arguments within the administration that this is a good thing that we could do, that would be helpful in every sense of the word, and the initiative comes from the White House, from Science Adviser Keyworth. So the question, then, is, do you know at this point? Are you going to defer?

Ms. **Fitzpatrick**. My information, Mr. Walgren, is that that item is included in the deferrals. Whether that actually happens, I can't say until the deferral is delivered to the Congress.

Mr. **Walgren**. Some deferrals have, and that has not. Is there another batch that's coming up?

Ms. **Fitzpatrick**. My information is that there is another deferral message coming.

Mr. **Walgren**. Well, let me ask—or raise the question—of whether this is really a deferral or whether this is a rescission, because the truth of the matter is that you have no money for it in 1987 and if you defer 1986 dollars into a budget year where you're providing no money—or plan to make no expenditures in that year—isn't that really a rescission? And shouldn't we be right up front about it, that the administration has just turned 180 degrees from the President's signature on last year's authorization bill, and that now we face a rescission in this area? And if you are clear about that, we could probably deal with it in the Congress; but if you take the soft road out of this, "Oh, we just don't have the money, we're going to defer it," we not only make it more palatable to those who do appreciate the value in this area but we don't get the shot at overturning a rescission for which we believe we have a pretty clear process in the Congress and one that we can come to grips with.

Are you really being fair with us by, No. 1, not sending it up? And second, not sending it up as it is, which is a rescission?

Ms. **Fitzpatrick**. Mr. Walgren, we do have money in the 1987 budget for steel and for the kinds of items that were listed in the steel initiative as being needed by the industry. We have about $3 million, and that will be spent on items such as near net shape casting, sensors, and control systems. We are also continuing our discussions with the steel industry about what their needs are and what research by the Federal Government they support, and what they want to do to contribute to the process and to the research itself. I'm very understanding and sympathetic of your views on the matter. I think steel is a very important industry, that we need especially to make some certain skills that are available in the national laboratories available to the steel industry.

Mr. **Walgren**. Well, we're very frustrated. And we really feel that when you can find $1 billion for net increases in nuclear weapon programs in the Department of Energy, that you can find $7.2 million for an initiative that has such tremendous potential and in which we are really the only existing players. The national laboratories have valuable expertise that they can contribute, and it doesn't exist anywhere else. So if we don't put those funds there, they clearly are not going to be brought to bear on this kind of a problem, and this is a very deep national priority.

Well, thank you very much, Mr. Chairman.

And I would want to encourage you to pursue that program.

Ms. **Fitzpatrick**. Yes, sir.

Mr. **Fuqua**. Thank you, Mr. Walgren.

Mr. Barton.

Mr. **Barton**. Thank you, Mr. Chairman.

Ms. Fitzpatrick, I just have a couple of questions.

In your written testimony you alluded to the fact that $2.1 billion is going to be allocated to the States; this is due to an overcharge with Exxon. You mention the allocation formula but don't really delineate it. Could you briefly discuss how that money will be allocated?

Ms. **Fitzpatrick**. Yes, sir. That money is being sent to the States under an order of the U.S. District Court for the District of Columbia. It is allocated to the States based on their consumption of petroleum products for a period, I believe, from 1975 to 1981. The reason for that was that the court could not identify exactly who ended up paying the overcharges in the entire stream of petroleum distribution, and, therefore, they simply said, well, let's give it to the States for their use based on how much petroleum was consumed in each State during that overcharge period.

Mr. **Barton**. So it's purely a consumption formula based on historical records?

Ms. **Fitzpatrick**. That is correct.

Mr. **Barton**. OK. And will that money actually be distributed in this coming month? In March?

Ms. **Fitzpatrick**. It is scheduled to be distributed next month, yes.

Mr. **Barton**. OK. Very good.

One other question. You are responsible for the conservation budget at the Department of Energy. Some of us at oil-producing States are very concerned about the price of oil falling below $15 a barrel, and we're going to be trying to convince our colleagues that we need an oil import fee. Would that, in your opinion, help American consumers continue to conserve energy if we were to stabilize the price somewhere in the $20 to $25 per barrel range rather than $13 to $15 per barrel?

Ms. **Fitzpatrick**. Mr. Barton, I can give you only my personal opinion. I know that the Department will be testifying—I think today or tomorrow—at a hearing on oil import fees, and I wouldn't want to wander out of my field and step on a toe.

Obviously, maintaining or raising the price of oil to the consumer encourages conservation and reduced consumption. That, in fact, is what the price run-up did to the industrialized world. And the response of increased conservation and efficiency and switching from oil is what has caused the current drop in prices and the inability of OPEC to even keep its own members in a concerted action.

So at least from that aspect, it's true that maintaining it would. The other, it has to be balanced off, of course, against what happens if American industry has to pay more for oil than the rest of the world does.

Mr. **Fuqua**. What about just certain parts of the United States, like the eastern seaboard?

Ms. **Fitzpatrick**. That's correct, there are——

Mr. **Fuqua**. The only people I know in Florida are west of the Mississippi River.

Mr. **Barton**. That's not quite true, Mr. Chairman. [Laughter.]

Ms. **Fitzpatrick**. Mr. Chairman, if you don't mind, I won't get into this argument.

Mr. **Barton**. Well, I appreciate your response. I know that's a difficult question. It's a difficult national policy question, but in my opinion in the long term it is important that we do encourage American citizens to conserve; and letting them gorge themselves on cheap oil for 2 or 3 years is not in our Nation's long term interests, in my opinion.

My final comment, I would encourage you in your position to continue to encourage the solar, photovoltaics, and thermal part of your program. I think there have been some tremendous strides made in those areas, due in large part to some funding and cooperative efforts between the Department of Energy and the private sector. I hope you will continue in that area.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Barton.

Mr. Fawell.

Mr. **Fawell**. I have no questions, Mr. Chairman.

Mr. **Fuqua**. Thank you very much for being here this morning. We appreciate also your two associates. We may still have some questions we wish answered later on, and we will notify you at the appropriate time.

[Additional questions and answers follow:]

Department of Energy
Washington, DC 20585

March 24, 1986

Honorable Don Fuqua
Chairman, Committee on Science
  and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

On February 27, 1986, Assistant Secretary Donna R. Fitzpatrick appeared before the Science and Technology Subcommittee on Energy Development and Applications to discuss the Fiscal Year 1987 budget authorization request for conservation, solar, and renewables.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Ingrid Nelson or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE FEBRUARY 27, 1986 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Conservation and Renewable Energy

February 27, 1986

Followup Questions

Ms. Donna Fitzpatrick

1. The FY 1987 budget request for the Conservation program is 58 percent below the FY 1986 appropriation level. The Solar program, including Geothermal, is reduced by 47 percent from last year. What plans have you formulated for these programs if the final FY 1987 budget should contain reductions but at a much less stringent level?

2. The Biofuels program supports both feedstock production and conversion processes. Many state colleges and universities are also active in feedstock production. Please comment on the possibility that DOE would spend money only on coordinating those state efforts rather than to be involved in the program itself.

3. We note significant cuts in Technology Transfer programs. How do you justify curtailment of this activity, which is the means by which DOE informs the outside world of its activities?

4. The Congressionally directed deficit reduction program extends over five more years at about an equal amount each year. At this present rate of reduction, how soon does the Administration plan to reduce to zero the Conservation and Renewable Energy programs?

5. The general perception over the last six years is that research has continued to grow, both in current and real dollars. At the same time, development programs, such as Conservation and Renewable Energy, have been reduced substantially. When the development programs are eliminated, will research continue to be increased, and at the expense of what; will research programs reach a plateau of constant effort; or will research programs then be reduced?

6. You indicated that further definition and guidelines with regard to the cooperative R&D venture concept should be available by the end of this fiscal year. Is the Administration intending to request a supplemental appropriation to implement the program in FY 1987?

7. With the decision in mid-1985 to discontinue the SMUD photovoltaic project, DOE found itself with nearly $10 million of unneeded funds which had been appropriated for SMUD. We are advised that the bulk of those funds were used to cover the so-called "Management Initiative" program. Please describe that program and provide to the Committee copies of the necessary reprogramming documents.

8. We are advised that the Mod-5 Wind Turbine is nearly completed, that the pieces are fabricated, that the base is poured, and that the assembly is about to begin. Please advise the Committee of the amount of funds necessary in Fiscal Year 1987 to complete the assembly, construction, and operation of the Mod-5 Wind Turbine in Hawaii.

9. The December 1985 "Report of the Solar Panel of the Energy Research Advisory Board to the United States Department of Energy" noted that "the fraction of solar energy funding available for industry and university research has disproportionately decreased, with a potential negative effect on the program's ability to meet long-term goals." Will this trend be continued in FY 1987, and if so, does the Department have any plans to address this concern?

10. We all recognize the need for fiscal restraint in light of the federal deficit. Those of us who voted for Gramm-Rudman (GR) did so out of our recognition that the federal deficit is indeed the greatest problem facing our nation, and that all federal programs will have to face very real reductions -- reductions which cut into the meat of the programs we support.

    Generally, it is estimated that GR would require spending to be cut across the board in the range of 10-15%. Why, then, does the Administration propose that funding for solar research be cut by 47% and conservation programs by over 58%? Do you agree that this is an appropriate level of federal support?

CONSERVATION AND RENEWABLE ENERGY BUDGET

Question 1: The FY 1987 budget for the Conservation program is 58 percent below the FY 1986 appropriation level. The Solar Program, including Geothermal, is reduced by 47 percent from last year. What plans have you formulated for these programs if the final FY 1987 budget should contain reductions, but at a much less stringent level?

Answer: Reductions have been taken in Conservation and Renewables programs and in the other civilian R&D programs such as Nuclear and Fossil Energy. No one program was singled out for budget cuts. The reductions in the Conservation and Renewable energy programs have been taken across all technologies and end-use sector programs in a balanced way. We will continue to address a balanced portfolio of technologies, using the monies requested for FY 1987 and funds for which we have requested deferral, while at the same time contributing to the Administration and congressional goal of reducing the Federal budget deficit.

Both Conservation and Renewable energy programs have developed multiyear planning analyses which indicate program opportunities and priorities. These analyses have been utilized in creating the FY 1987 budget submitted to the Congress and would be used to determine the best application of any additional funds.

SOLAR ENERGY

Question 2: The Biofuels program supports both feedstock production and conversion processes. Many state colleges and universities are also active in feedstock production. Please comment on the possibility that DOE would spend money only on coordinating those state efforts rather than to be involved in the program itself.

Answer: The Biofuels Program actively seeks participation from all sectors such that the best available resources can be applied to the varied and complex research problems facing the program. An excellent example of this is the research that the program conducts with land grant colleges on a competitive basis as part of its feedstock program and which recognizes their expertise in this area. While these universities frequently have established capability in agronomy and forestry, the DOE funds help to precipitate a dedicated effort on their part in energy related research as opposed to the conventional agricultural and paper products research which is usually the focus of ongoing programs. It is our expectation that many of these initiatives will develop a sufficient continuing interest in energy related research that levels of cost sharing will rise over time and DOE funding requirements can eventually be directed more toward coordinating these activities while continuing to provide substantive input to the effort. It is expected that the Biomass program will continue in the interim to utilize the expertise of state colleges and universities on a competitive basis, especially within the feedstock program element.

TECHNOLOGY TRANSFER

Question 3: We note significant cuts in Technology Transfer programs. How do you justify curtailment of this activity, which is the means by which DOE informs the outside world of its activities?

Answer: The generic Technology Transfer activities funded under the referenced line items entail publication of reports and fact sheets for the technical and general audience, operation of inquiry referral services, and technical assistance to entrepreneurs and practitioners. Each of these activities will be continued at levels commensurate with overall technology program funding and consistent with the relative priority of research funding versus information services. Additionally, the National Awards program is an important mechanism for recognizing the ingenuity and creativity of the private and non-federal public sectors applying the results of R&D to practice and is a primary technology transfer mechanism. It is especially important to note that national user facilities at the DOE laboratories, professional seminars and conferences, cost-shared collaborative research, publications in professional journals, and laboratory sabbatical or post doctoral programs all fulfill critical technology transfer objectives. These types of activities are incorporated within each research program and will remain vital ingredients in our overall technology transfer effort.

CONSERVATION AND RENEWABLE ENERGY BUDGET REDUCTIONS

Question 4: The Congressionally directed deficit reduction program extends over five more years at about an equal amount each year. At this present rate of reduction, how soon does the Administration plan to reduce to zero the Conservation and Renewable Energy programs?

Answer: The President's FY 1987 budget, including outyear projections, is intended to meet the Gramm-Rudman-Hollings targets. The outyears for the Conservation and Renewable Energy program show constant buying power at the FY 1987 level. We believe that it is important in light of our Nation's long range security that we develop a technology base which will allow industry to further develop these technologies when it is considered most appropriate to do so. The FY 1987 request and the associated outyears in the budget are sufficient to provide this base for our long-term energy security.

CONSERVATION AND RENEWABLE ENERGY

Question 5: The general perception over the last six years is that research has continued to grow, both in current and real dollars. At the same time, development programs, such as Conservation and Renewable Energy, have been reduced substantially. When the development programs are eliminated, will research continue to be increased, and at the expense of what; will research programs reach a plateau of constant effort; or will research programs then be reduced?

Answer: The applied research programs, as well as the other programs of the Department, have been critically reviewed in light of the need to accomplish reduced Federal outlays as well as the need to focus Federal investment in more basic research which will benefit a broad cross section of industrial interests over the longer term. In the case of Conservation and Renewable Energy, the proposed reductions in new budget authority reflect a variety of considerations including the successful completion of previous lines of research, a focussing of public investment in the more basic areas most appropriate to the Federal role in technology research, and difficult decisions among competing technical priorities. The Budget Request reflects a commitment, within available resources, to sustaining a balanced effort across major technology options in a manner which focusses expenditures in the highest priority scientific and technical investigations. The Department continues to consider the Conservation and Renewable Energy technologies important ingredients of the Nation's energy resource base over the long term and some continuing level of research investment on our part is likely, subject to the annual appraisal of resources available to the Government.

COOPERATIVE R&D VENTURES

Question 6: You indicated that further definition and guidelines with regard to the cooperative R&D venture concept should be available by the end of this fiscal year. Is the Administration intending to request a supplemental appropriation to implement the program in FY 1987?

Answer: Details of how this mechanism might work are under discussion. Specifics of such an agreement, including the necessary funding, will have to be worked out with industry sponsors. If FY 1987 funding is necessary for a specific project, a reprogramming request would be submitted.

Question 7: With the decision in mid-1985 to discontinue the SMUD photovoltaic project, DOE found itself with nearly $10 million of unneeded funds which had been appropriated for SMUD. We are advised that the bulk of those funds were used to cover the so-called "Management Initiative" program. Please describe that program and provide to the Committee copies of the necessary reprogramming documents.

Answer: The Department's management initiatives are designed to improve the efficiency and effectiveness of Departmental management systems, to take advantage of economies available through increased or improved utilization of private sector capabilities, and to place the Department's financial systems on a more business-like basis. These initiatives not only improve the current Departmental operations, but provide for the possibility of additional savings in future years.

One of these initiatives involves financial systems reforms which include the improved management of the deobligation of multi-year funds. Deobligations may occur due to contract close-out, contractor defaults, or other instances of contractual dollar reductions, such as cost disallowances based on audit results. Under this initiative, such deobligations are reported and evaluated to determine whether or not the funding should be retained in the program where it was originally appropriated. If it is determined that there is no compelling reason to retain these funds in that program area, they are used to offset the budget authority in the following fiscal year for programs in the Interior and Related Agencies Appropriations Act. Programs under the Energy and Water Development Appropriations Act are reduced to reflect the amount of the prior year deobligation management savings estimated for that program. Subsequently, on a quarterly basis during the fiscal year, programs receive funds which have been deobligated from prior 5-year awards.

A total of $9.5 million was appropriated for the Sacramento Municipal Utility District project (SMUD) in FY 1985. A total of $2.5 million was reprogrammed for the MOD-5 Wind program in compliance with Committee Report language which supported the FY 1985 Supplemental Appropriations Act. Departmental reprogramming letters are provided for the record. The $7.0 million balance was used as a management initiative reduction in FY 1985 and FY 1986. Currently there are no unobligated funds remaining for SMUD.

Department of Energy
Washington, DC 20585

SEP 26 1985

Honorable Tom Bevill
Chairman, Subcommittee on Energy
  and Water Development
Committee on Appropriations
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

This is to advise you of the Department of Energy's plan to reprogram funds within the Energy Supply Research and Development appropriation. It is the Department's intention to transfer $2.5 million in construction funds from the Sacramento Municipal Utility District (SMUD) project to the Mod-5 wind turbine.

Report language accompanying the FY 1985 Supplemental Appropriations Act, Public Law 99-88, instructed the Department to proceed expeditiously to reprogram $2.5 million from available funds to maintain the schedule on the Mod-5 wind turbine. This reprpgramming will not adversely impact the SMUD project since the SMUD Board of Directors on April 18, 1985, approved a recommendation by their Planning Committee to suspend indefinitely further development of the proposed 100 megawatt project.

Your early consideration of this proposal would be appreciated. We will be glad to provide any additional information you may need.

Yours truly,

Elizabeth E. Smedley

Elizabeth E. Smedley
Controller

cc: Honorable John T. Myers
Ranking Minority Member
Subcommittee on Energy and
  Water Development
Committee on Appropriations
House of Representatives
Washington, DC 20515

Department of Energy
Washington, DC 20585

SEP 26 1985

Honorable Don Fuqua
Chairman, Committee on Science
and Technology
House of Representatives
Washington, DC 20515

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Yours truly,

Elizabeth E. Smedley

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Controller

cc: Honorable Manuel Lujan, Jr.
Ranking Minority Member
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Department of Energy
Washington, DC 20585

SEP 2 6 1985

Honorable Mark O. Hatfield
Chairman, Committee on Appropriations
United States Senate
Washington, DC 20510

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Elizabeth E. Smedley

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Controller

cc: Honorable J. Bennett Johnston
Ranking Minority Member
Subcommittee on Energy and
Water Development
Committee on Appropriations
United States Senate
Washington, DC 20510

Department of Energy
Washington, DC 20585

SEP 26 1985

Honorable James A. McClure
Chairman, Committee on
  Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

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Elizabeth E. Smedley

Elizabeth E. Smedley
Controller

cc: Honorable J. Bennett Johnston
  Ranking Minority Member
  Committee on Energy and
    Natural Resources
  United States Senate
  Washington, DC 20510

SOLAR ENERGY

Question 8: We are advised that the Mod-5 Wind Turbine is nearly completed, that the pieces are fabricated, that the base is poured, and that the assembly is about to begin. Please advise the Committee of the amount of funds necessary in Fiscal Year 1987 to complete the assembly, construction, and operation of the Mod-5 Wind Turbine in Hawaii.

Answer: Fabrication of all major hardware has been completed and final assembly is nearly complete at Boeing's plant in Seattle, Washington. The concrete foundation and the tower have been installed at the site in Hawaii. Shipment of the assembled machine to the site was scheduled for April 1986. To complete the project would require an estimated $16.2 million in addition to funds currently available for expenditure; assuming no major problems were encountered. The Department has proposed to end the MOD-5 effort with documentation of equipment design in order to focus outlays on higher technical or scientific priorities.

ERAB REPORT

Question 9: The December 1985 "Report of the Solar Panel of the Energy Research Advisory Board to the United States Department of Energy" noted that "the fraction of solar energy funding available for industry and university research has disproportionately decreased, with a potential negative effect on the program's ability to meet long-term goals." Will this trend be continued in FY 1987, and if so, does the Department have any plans to address this concern?

Answer: As shown in the attached table, the estimated funding percentages going to universities and other entities has remained fairly constant over the FY 84 - FY 87 period. The Department recognizes the special value and capabilities of university and industrial researchers and these capabilities are included in the program where a match exists between these capabilities and the overall technology development objectives, which are formulated with inputs from industry and universities, and which form the basis of overall program plans. In FY 1987 we will continue to match the capabilities of various researchers with technical priorities in order to best advance toward program goals. We expect that universities and industry will continue to play an important role in meeting the objectives of the solar research program.

RENEWABLE ENERGY PROGRAM
FUNDING DISTRIBUTION

Programs	FY 1984 %	FY 1985 %	FY 1986 %	FY 1987 %
SOLAR ENERGY				
Solar Bldgs				
-DOE Laboratories	56%	57%	50%	59%
-University Researchers	8%	12%	19%	18%
-Other (i.e., Industrial Firms)	36%	31%	31%	23%
Photovoltaics				
-DOE Laboratories	48%	39%	50%	69%
-University Researchers	11%	15%	15%	19%
-Other (i.e., Industrial Firms)	41%	46%	35%	12%
Solar Thermal				
-DOE Laboratories	41%	44%	51%	47%
-University Researchers	5%	6%	10%	11%
-Other (i.e., Industrial Firms)	54%	50%	39%	42%
Biofuels				
-DOE Laboratories	41%	31%	32%	40%
-University Researchers	25%	17%	18%	20%
-Other (i.e., Industrial Firms)	34%	52%	50%	40%
Wind Energy				
-DOE Laboratories	25%	26%	54%	66%
-University Researchers	6%	4%	8%	7%
-Other (i.e., Industrial Firms)	69%	70%	38%	27%
Ocean Energy				
-DOE Laboratories	46%	55%	55%	64%
-University Researchers	18%	18%	6%	16%
-Other (i.e., Industrial Firms)	36%	27%	39%	20%
Other-Solar				
-DOE Laboratories	52%	48%	41%	39%
-University Researchers	0%	0%	0%	0%
-Other (i.e., Industrial Firms)	48%	52%	59%	61%

CONSERVATION AND RENEWABLES BUDGET REDUCTIONS

Question 10: We all recognize the need for fiscal restraint in light of the federal deficit. Those of us who voted for Gramm-Rudman (GR) did so out of our recognition that the federal deficit is indeed the greatest problem facing our nation, and that federal programs will have to face very real reductions -- reductions which cut into the meat of the programs we support.

Generally, it is estimated that GR would require spending be cut across the board in the range of 10-15%. Why, then, does the Administration propose that funding for solar research be cut by 47% and conservation programs by over 58%. Do you agree that this is an appropriate level of federal support?

Answer: Reductions have been taken, based upon government-wide and program specific priorities, in both the Conservation and Renewable Energy programs and the other civilian R&D programs such as Nuclear and Fossil Energy. No one program was singled out. The reductions in the Conservation and Renewable Energy programs have been taken across all technologies and end-use sector programs. We believe that adequate funding has been provided in the FY 1987 budget request to allow the fundamental technical issues in each area of research to continue to be addressed across a balanced portfolio of technologies. We intend to maximize our resources to advance the state of the art in these technologies, while at the same time contributing to the Congressional and Administration goal of reducing the federal budget deficit.

Ms. Fitzpatrick. Thank you, Mr. Chairman.

Mr. Fuqua. Thank you very much.

Our first panel is Mr. Scott Sklar with the Solar Energy Industries Association, accompanied by Mr. Roger Little of the Spire Corp. and Mr. David Gorin, also with SEIA, and a gentleman that is no stranger to this committee, having served on the science advisory panel many, many years ago, a constituent of Mr. Barton's, and I would like to call on Mr. Barton to introduce Dr. Hesse.

Mr. Barton. Thank you, Mr. Chairman.

As you indicated, Walter Hesse is no stranger to this committee. My predecessor in the Congress, the Honorable Olin E. "Tiger" Teague, whose portrait hangs on the wall, was a close friend and confidant of Mr. Hesse.

Dr. Hesse was educated at Purdue University. He has more degrees than we've got time to read here in this hearing, but he's been very active for many, many years in solar research. He currently serves on the advisory board of SERI—the Solar Energy Research Institute; he is on the board of directors of SEIA—the Solar Energy Industries Association; he is national vice president and chairman of the Solar Thermal Power Division; he has formerly served as a member of the scientific panel to the congressional House Committee on Science and Astronautics, where I think you first met him; he is a member of the advisory board for the Joint Task Force II of the Joint Chiefs of Staff; he's a member of the Texas Commission on Atomic Energy; he's a past chairman of the board for the Aerospace Education Foundation of the Air Force Association. So I'm sure that his testimony is going to be enlightening, and I look forward—as I'm sure that the other members of this committee do—to hearing what he has to say.

Mr. Fuqua. Thank you very much, and we're also glad to have all of you back again.

Mr. Hesse. Congressman Barton, I sure appreciate that. We have a certain order we'd like to go through, so if we can do that?

Mr. Fuqua. Mr. Sklar, I think you're first.

Mr. Gorin. I'll go first.

Mr. Fuqua. Oh, OK.

STATEMENT OF DAVID GORIN, EXECUTIVE VICE PRESIDENT, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. Gorin. Thank you very much, Mr. Chairman. I am David Gorin, executive vice president of the Solar Energy Industries Association, a national trade association that represents solar, thermal, and photovoltaic manufacturers and component suppliers.

I have prepared a written statement, but I would like to take just a very short time to provide an overview of our views on the fiscal year 1987 authorization for solar.

Our comments primarily are directed at the solar buildings, solar thermal, and photovoltaics portions of the budget under discussion. The representatives with me today from the divisions of our association will present the specific views of the technologies, and all of us together, with our director of Government relations, Scott Sklar, who is also representing the SEIA Heating and Cooling Division, will be happy to answer your specific questions.

First, it is our belief that should the Gramm-Rudman Act produce the 15-percent reduction of fiscal year 1986 budget, that cut would inordinately impact on the solar budget, and that budget has been cut repeatedly each year since 1981. Although we are certainly sensitive to the budget deficit, we must point out that the solar budget cuts have been so severe over the last few years that further cutting could invalidate the remaining parts of the program. The solar program budget, that part that directly impacts on our industry, has gone from $125 million in fiscal 1983 to about $69 million in fiscal 1986, and the proposed budget for fiscal 1987 would be at about the $45 million level. We believe that this latest proposal would be wholly inadequate.

My second point concerns the Solar Energy Research Institute, a laboratory that the industry considers to be extremely important to the industry's future growth. DOE is wisely consolidating solar research at SERI, a move that we certainly applaud. It is important that in times of shrinking R&D funding, the available resources be harnessed to continue the important research function. To further improve this effort, we recommend that the Solar Energy Research Institute have a distinct and separate appropriation and no longer be hidden in the overall Department of Energy R&D budget. Such a line item will be most useful to the industry and to the Congress in assessing the effectiveness and benefits of the research done at SERI.

My third point relates to the importance of maintaining public awareness. Increased public awareness of solar is very critical to our industry, and we strongly recommend that the Department of Energy technical and consumer information programs be maintained. We are particularly interested in the National Appropriate Technology Assistance Service [NATAS] and the Conservation and Renewable Energy Information and Referral Service [CAREIRS]. These services provide citizens with a central source for both technical and consumer information and assistance. DOE should be instructed to develop these programs, which are proactive and can successively assist in transferring research information developed in Federal labs to the industry and the public on an ongoing basis. Our association strongly recommends that this committee legislatively direct DOE in regard to these programs.

SEIA strongly opposes the current Department of Energy practice of taxing line items for management and administrative overhead. Because of this technique, the funding of DOE programs does not mean that the moneys are actually spent for the purpose for which they have been budgeted. The solar industry would prefer that funds for administrative functions of DOE be identified on their own lines, and that funds for solar programs not be burdened by having some of those precious funds diverted from their intended purpose. Only by delineating how the funds are to be used can the industry and Congress develop an adequate picture of the actual way in which the funds are expended.

International programs carried out by DOE in conjunction with the Department of Commerce in support of the renewable industry should be maintained. The support now given to the industry that allows for increased participation of U.S. companies in overseas trade exhibitions is very important to helping our companies maintain their international competitiveness.

We also urge continued support for specific programs of technology transfer. The current solar buildings program has successfully integrated both active and passive solar, and it is now time to bring in the conservation aspects, which have been treated as a separate program. We suggest that these programs be combined and that greater emphasis be placed on transmitting technology from Government facilities and scientists to industry and the private sector.

Finally, in the area of cooperative industry/Government R&D, as proposed by the Department of Energy along the lines of the Microcomputer Electronics Corp., we must at this time oppose that form of joint effort and have so informed Secretary Herrington in a recent letter to him that we would like to submit for the record.

[Material to be supplied appears as an attachment to Mr. Gorin's responses to additional questions.]

Mr. Gorin. Our opposition is based primarily on the very small size of the companies in our industry, the lack of capital resources available for such joint efforts, and the general state of maturity of the industry.

Thank you again for this opportunity to present our views, and our divisional representatives will now address the specific program areas that they represent.

[The prepared statement of Mr. Gorin follows:]

SEIA

SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 503 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036 (202) 483-6225

TESTIMONY

by

DAVID GORIN
EXECUTIVE VICE PRESIDENT
SOLAR ENERGY INDUSTRIES ASSOCIATION

before the

Subcommittee on Energy Development and Applications of the House Science and Technology Committee Hearings

FEBRUARY 27, 1986

WASHINGTON, D.C.

Prepared by:
Scott Sklar
Director of Government Relations, SEIA

INTRODUCTION

Mr. Chairman, I would like to thank you and the Committee for allowing the Solar Energy Industries Association (SEIA), the national trade association for the solar thermal and photovoltaics manufacturers and component suppliers, to testify regarding the U.S. Department of Energy's solar research and development budget for FY'86 and FY'87. I will present a very brief overview and the representatives of our association's three technical Divisions--Solar Heating & Cooling, Solar Thermal Power, and Photovoltaics--will also present some testimony, and with Mr. Scott Sklar, SEIA's Director of Government Relations, will answer any of your questions.

SOLAR ENERGY BUDGET

The Solar Energy Industries Association, when speaking on the U.S. Department of Energy's solar research and development budget, is focussing on the parts of that budget which assist the solar thermal and photovoltaic industries, as well as the international and information programs including support for the federal laboratories, specifically the Solar Energy Research Institute (SERI). SEIA has calculated that these specific programs which accounted to more than $150 million in FY'83 now accounts for $75 million in expenditures. Although the solar industry is sensitive to the deficit, we must point out that the solar budget has been drastically cut over the last five years to such an extent that further cuts would totally undercut the federal effort. At some point further cuts will invalidate the U.S. solar program. Making large cuts in the solar and renewables budget while cutting the larger nuclear budget slightly is both inequitable and shortsighted. SEIA's Division representatives will testify on the priorities in each program so that this subcommittee can make sound judgements on the priorities of these programs. Though we accept that everyone must share budget cuts, SEIA urges you to hold fast against precipitous cuts of this program.

PROGRAM ACCOUNTABILITY

The Solar Energy Industries Association is concerned that the administrative, accounting, and program practises as currently done, do not provide for responsible oversight of the solar and renewables programs within the U.S. Department of Energy. SEIA would like to propose two recommendations to the Congressional authorization and appropriations committees that would make accountability and oversight easier in regard to these programs:

- o set-aside monies in a line items to meet administrative and management requirements;
- o place the Solar Energy Research Institute in its own line-item.

Currently, the solar industry, and we believe the U.S. Congress, is not fully aware of the actual appropriations in our programs. That is because the U.S. Department of Fnergy has a series of internal administrative and management programs where line items are "taxed" across the board. In our opinion, not only ate the different line items "taxed" at different rates but at different times. Contrary to agency assurances, the solar programs are not treated in the same way as the larger conventional energy programs. Even if treatment was equitable, the fact that the solar programs are so small makes the "taxing" a real deterrant to planning.A set aside for the myriad of agency requirements will then provide the agency and the Congress with the assurance that the money appropriated will actually go towards the programs funded.

In addition, the funding of the nation's premier research facility, SERI, is accomplished through a practise of forced tithing at each program level. Although the tithing has generally worked, the fact is that SERI ought to be funding openly. This provides greater stability for SERI and provides the U.S. Congress and the solar industry an upfront view of how the program research pie is divided. SEIA urges the Committee to support SERI at current levels in a separate line item function.

SOLAR PROGRAM HELPING THE INDUSTRY

Several programs are included in the U.S. Department of Energy's solar reasearch and development program that has helped the industry and should be continued. The international program has supported the CORECT process, a federally mandated interagency coordinating group to promote a more cooperative national approach fostering the export of solar and renewable energy products. The international program also contributes through the U.S. Department of Commerce towards international trade shows which are cost-shared with the U.S. solar industry. These programs have been effective and deserve continued support.

The DOE federally supported technical service, called the Natioanl Appropriate Technology Assistance Service (NATAS) has been very useful through its toll free phones and its computer data base to refer individuals and companies to the appropriate industry sectors, as well as by assisting people with technical problems that are beyond the scope of the hundreds of small businesses that comprise the solar industry. The program needs to be expanded to transfer the useful information into a more active approach to help the U.S. solar industry and the Congress should continue their support of this cost-effective program.

Finally, the DOE conservation program monies that involve research and application ought to be merged with the current DOE solar buildings program which has been very effective in integrating design and active & passive solar applications into an integrated package of energy savings. Conservation is a component of this, and these programs have been separated far too long due to agency and constituency politics. SEIA also urges that the Committees include clear legislative language which directs the Department of Energy to carry out programs which effectively transfer the results of federal research to the industry. An attempt by SEIA to have funds set aside for this purpose was not followed throug- by the Congress for FY'86 and we urge you to support technology transfer in FY'87.

CONCLUSION

The U.S. Department of Energy solar research and development budget has been an extremely useful program to aide the fledgling solar industry to enter the market place. However, the program to continue to be effective is funded at its lowest base level currently. Certain accounting and appropriations practises will make the solar budget easier to administer oand oversee. The international and NATAS programs have been effective and should be continued. Federal research needs to be more effectively transfered to the solar industry and the nation's solar research facility needs continued level support. Consolidating certain conservation and solar buildings programs make sense with decreasing revenues.

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STATEMENT OF SCOTT SKLAR, VICE PRESIDENT FOR GOVERNMENT OPERATIONS, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. **Sklar**. I'll take over on the solar heating and cooling side, which is the largest part of the industry in terms of overall annual sales.

As you know, 85 percent of the low- and medium-temperature solar manufacturers have really been in business only since 1978. We are a very young industry. Over the last 8 years, the environment for solar in terms of Government support has neither been fair nor consistent. I'd like to point out to the committee that in the Assistant Secretary's testimony, that the building sector accounts for approximately 36 percent of our national energy consumption. And if you look at the budget they propose, the building side of it gets the teeniest, tiniest amount. In fact, this small program only gets $8.5 million, of which actually $1.4 million goes toward congressionally directed projects. So an even smaller amount of that budget actually winds up for research in industry or in programs.

The program has been successful and very cooperative with the industry. The buildings program has done successful research in thin films, or foils, and collector construction—which has the potential to reduce collector installed costs substantially; research into substitution materials and high performance materials to increase both active and passive solar output; research into integrated systems incorporating conservation, materials, and active and passive solar applications together to improve overall building energy ratings.

One of the recommendations that our association has made in combining the conservation and solar buildings programs budget is that we can't look at each part of the elephant and decide how we're going to deal with it. You have to take the whole elephant together, take a look at all the technologies that make it work, and see if we can be effective. Since funding is going down in these programs, we might as well mix them into a more usable, workable situation.

The potentials for the solar buildings program in the next few years are very high and will benefit this industry very strongly. We are, the Industries Association, collaborating with the Department of Energy to develop a national design and installation manual so that we make sure that we standardize on large projects a kind of installation process throughout the United States that would build confidence in our industry.

Technology dissemination on solar energy from research programs at the national laboratories is going to be upgraded. We have had a lot of problems in this industry of getting research into the hands of, basically, a small business sector. It has all been in good will by the national labs to get this information out, but SERI is taking, I think, some unprecedented moves with us to be much more proactive to get this information out to us.

Finally, we have been working, through this CORECT process, to help us with exports. The United States leads in all the solar technologies you're about to hear of today, and this process to help the different Federal agencies use ongoing programs to promote our technologies abroad is very important to us.

I'd like to finish by saying that the solar industry is a small business industry. It is unable to conduct the kind of research necessary to integrate their products with other products to achieve maximum effectiveness. The consumer tax incentives, as you know, have not yet been extended. This has been, really, very traumatic for this industry. It would be horrible if the Federal research effort was also pulled out from under this industry at a time when solar hot water, in particular—we have been able to sell our products through national retail chains only in the last 2 years, like Sears & Roebuck, Woodies, Wannamakers, Burdines.

This industry represents a major step in energy—domestically produced, environmentally safe. We hope that the DOE solar buildings program has been cut as far as it should have, and must be maintained at near to current levels.

Thank you.

[The prepared statement of Mr. Sklar follows:]

SEIA

SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 503 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036 (202) 463-6225

TESTIMONY

by

SCOTT SKLAR

DIRECTOR OF GOVERNMENT
RELATIONS

representing

SEIA's HEATING & COOLING DIVISION

before the

Subcommittee on Energy Development and
Applications of the House Science and
Technology Committee

February 27, 1986

Washington, D.C.

Joe Conrad, Chairman
(The Amcor Group Ltd)
Dick Joyce, Vice Chairman
(Morning Star Manuafacturing Inc.)
SEIA Heating & Cooling Division

SOLAR ENERGY INDUSTRIES ASSOCIATION

1.0 Introduction

The technology for the collection of sunlight for water and space heating has been available in the marketplace since the 1973 oil boycott with over 85 percent of the low and medium temperature solar manufacturers in business since 1978. Over the last eight years the environment for solar, in terms of government support, has neither been fair or consistant. The solar buildings and energy systems program was cut 45% from FY'84 to FY'85. This small $8 million program that benefits the active and passive solar industries has provided some very positive results for the solar energy industry which is comprised totally of small businesses. With $1.9 million going towards Congressionally directed projects, an even smaller amount eventually gets to industry-oriented programs.

2.0 Solar heating & cooling

Solar heating and cooling provide the most efficient means to heat water and space for low-temperature applications in homes and commercial buildings. The United States should not waste our other precious finite fuels on uses that are more efficiently accomplished by solar energy.

2.1 Federal program by the U.S. Department of Energy

The U.S. Department of Energy's solar buildings program has benefitted the solar industry in many ways including:

- o Research in the use of thin films or foils in collector construction, which has the potential to reduce collector installed costs substantially;
- o Research into substitution materials and high performance materials to increase both active & passive solar output;
- o Research into integrated systems incorporating conservation materials and active/passive solar applications to improve overall energy savings.

In order for this young industry to become fully viable in the marketplace, the U.S. Department of Energy research program must be continued at the minimal level. Since this solar budget has been cut more than any other renewable energy line-item, SEIA hopes the Committee will maintain level funding and support its goals.

2.3 Potentials for the solar buildings program

Several programs are in process that will have positive benefits for the solar energy industry and the American consumer including:

- o Development of a national design and installation manual;
- o Technology dissemination to the solar industry from research programs at the national laboratories;
- o Facilitation program through CORECT to assist the industry in developing new export markets such as Caribbean basin.

2.4 Conclusions

The solar industry is a small business industry is is unable to conduct the kind of research necessary to integrate their products with other energy conserving products to achieve maximum effectiveness. The consumer tax incentives have not been extended and the industry is in a tenuous situation. Loss in federal R&D support would hurt even more. During the last two years, the solar hot water industry has been able to sell its products through major retail chains such as Sears & Roebuck, Woodward & Lothrup, Wanamakers, and Burdines. This represents a major step in the maturing of the solar industry. The DOE solar buildings budget has been cut far more than other programs and must be maintained at near-to-current levels.

Mr. FUQUA. Mr. Hesse.

STATEMENT OF WALTER J. HESSE, PRESIDENT, ENTECH, INC., DALLAS, TX, AND CHAIRMAN, SOLAR THERMAL POWER DIVISION, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. HESSE. Mr. Chairman, I again want to thank Congressman Joe Barton for that splendid introduction. It's always great to have a fellow Texan on this committee.

I am president, now, of ENTECH, Inc, in Dallas, TX, and we have products that concentrate the sunshine for photovoltaics as well as high temperature steam and water systems. And our heritage goes back 10 years, and our only business is solar energy today. And as reported earlier, I am also chairman of the Solar Thermal Power Division, and it's that role that I speak to you today.

Our division of SEIA consists of more than 30 member companies, 5 large corporations, several utilities, and more than 2 dozen small business companies. We work with high temperature—over 300 degrees Fahrenheit—solar generated steam, and apply this steam energy to industrial process applications or use it to generate electricity by steam turbines or other types of engines.

Some of our companies have fielded a few significant solar installations, thanks to the combination of the Federal and State energy tax credits plus a good Government R&D program. However, most of our companies' activities today are devoted to advanced R&D for improved component efficiencies and lower cost in order to achieve an end product that will be competitive without the tax credits.

As a group, we believe that it is imperative for the solar thermal R&D program to remain at a $30-million level, the average of the last 2 years, if we are to retain a viable technology industrial base.

We're really at a critical juncture in industry today. Since 1982, the budgets for our activities have dropped from $55 million down to today's proposed $15 million. We're also concerned about the potential of deferrals, because that's another technique of getting the budgets reduced even further. Since 1981, 30 percent of the major companies involved in developing solar thermal technologies have discontinued their research activities or have dropped out of this field.

SEIA has recently made an industrial survey and posture analysis of our industry, and the briefing papers are included as a part of this briefing, and it will be appended. I'd like to give you the summary conclusions because they are most noteworthy.

Point one, the current soft market for oil and gas dominates the environment in which our companies operate.

Two, there has been a major decline in the solar thermal industry in the last 4 years.

Three, the industry expects the decline to continue because no near-term market is in sight, and the DOE budgets have continued to fall.

Four, the industry has invested and is willing to continue to invest private funds in solar thermal research because it remains optimistic about the eventual potential of these technologies.

And last, industry believes that a strong Federal role remains essential because of falling energy prices and high technical risks in certain areas.

This last point is a critical one. Industry needs a strong and adequate R&D program, and we recommend that during this so-called quiet energy period—instead of the energy panic period—while we have low oil prices, we really do our job and conduct a good R&D program.

Now, our country really needs a strong solar industry. We tend to forget some of the key issues that play in our favor. If we have a good program, we decrease the dependency on reported oil with its negative trade balance. We certainly improve our environment with nonpolluting solar energy, less smog, CO_2, and other waste. We create many new jobs because the solar energy business is labor-intensive. We allow utilities to build plants in modular form and quickly, not 8 to 15 years for some coal and nuclear plants. Luz Engineering Co., one of our member companies, for example, installed a 30-megawatt electric powerplant in 10 months in 1985.

We can create exports and help our trade balance. Most developing nations are in great need for nonpolluting solar energy, and a healthy U.S. solar industry will generate many affordable export products. I might say that many of these developing nations are in excellent sunshine conditions.

Solar thermal power, if we get a decent program, can certainly improve the image of our country and national security. Right now, the United Stated is perceived as a country that uses too much energy; and if we were to get a good solar program in a free society, we would be perceived as a country that took the right opportunity and not toxify areas of the plant with high-level radioactive waste and not create a lot of CO_2 and other things that go with fossil fuels. And we should also keep in mind that by sinking a few tankers, an oil supply line can be cut off; and blowing up one strategic nuclear powerplant anyplace in the world can cripple a major portion of land area.

Another item that has recently come to the forefront is that solar thermal power can be applied to space programs. The solar thermal technology will have good applications within this national defense and space program because satellites and space stations of all types—for communications, reconnaissance, and observation vehicles—must have electric and thermal energy in order to function. And these sources will come either from photovoltaics or solar thermal energy systems. And I daresay that, since the recent blowup of the space shuttle—Mr. Chairman, your State of Florida will take extraordinary precautions that we never have a blowup on the launchpad or near the launchpad when we launch some nuclear powerplants.

So the star wars activities and other defense satellites, I am sure, are going to be looking more seriously at solar energy for supplying those powers.

We should also remember that solar thermal power has unique characteristics. We can make electricity either from solar thermal power or from its sister technology, photovoltaics. And for certain applications, one technology has advantages over the other. So each will be used where the fit is best, and since solar thermal power is generated by concentrator, it yields certain unique characteristics. One, it's got easy storage; you merely store the working fluid that is being heated. And two, you can attain very high temperatures, 2,000 to 5,000 degrees Fahrenheit or even higher, and then use that for solar engines, solar furnaces, or solar chemical reactions.

Now, we've made a lot of progress in the last year, both in the Federal and in the private sector. Some key items in federally sponsored programs were the completion of the molten salt electric experiment; we completed the Vanguard Dish-Stirling project with a record peak efficiency of 31.6 percent, and an all-day efficiency of 25.2—that's solar to electricity; selected contractors for small community solar experiments at Osage City, KS and Molokai, HI; awarded innovative dish concentrators and advanced heliostat contracts, and completed the first year of the cooperative 3-year power production phase of the 10 megawatt solar-one powerplant, Barstow.

Also, in the private sector some significant things have happened. The LUZ SEGS I initiated operation of the 14.7 megawatt parabolic trough project. The LUZ SEGS II, installed in only 10 months, started operation of the world's largest solar powerplant, 30 megawatts, at Daggett, CA; the LaJet Solar Plant 1 initiated operation of an almost 5 megawatt powerplant, and McDonnell Douglas/United Stirling initiated prototype limited production of parabolic dish/stirling modules.

By far, the most significant one is the LUZ SEGS II of the 30 megawatt powerplant. That was done based on tax credits, accelerated depreciation, and the State credits as well as the Federal ones. Now, the expiration of these favorable tax credits is a key reason for continuation of an adequate Federal R&D Program. We've got to make solar energy cost-effective without these tax credits.

In summary, I'd like to say that the solar research teams in industry, laboratories, universities, and utilities have evolved over 10 years, and they have matured into an effective working unit with a good network of interaction and communication. Fundings by the DOE, through such organizations as Sandia and SERI, have played a major role in demonstrating the viability of the industry teams. The teams are enthusiastic and dedicated; they would have to be after being sifted and consolidated through this continued budget reduction process since 1980.

The proposed budget recommendation of only $15.3 million literally would decimate these teams, and many would disappear, as some have already done. It is important to remember that DOE has invested about $1 billion in solar thermal energy over the years and that industry has invested an additional $200 million to $300 million; thus, if the R&D teams disappear, then these major investments literally will be mothballed.

We have a 5-year plan in the [SEIA] Solar Thermal Industry Group which called for a $40 million funding level; and in the spirit of helping reduce the overall Federal deficit, we have restructured that plan to progress at a slower rate of $30 million a year.

Thus, in our conclusion, we recommend the following: That the R&D funding level be continued at no less than $30 million, about the average for the last 2 years. We note, by the way, that the total

DOE budget has increased from $11.9 billion to $12.1 billion, an increase of $128 million. And the proposed solar budgets have literally been cut in half.

Point two, should there be a tax on imported oil, which the majority of our members support, a portion of it be directed to solar thermal research to enhance the $30 million to help assure earlier energy independence.

I thank you very much, Mr. Chairman.

[The prepared statement of Mr. Hesse follows:]

STATEMENT OF

WALTER J. HESSE

CHAIRMAN
SOLAR THERMAL DIVISION
SOLAR ENERGY INDUSTRIES ASSOCIATION

BEFORE THE
SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS
OF THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

27 FEBRUARY 1986

1.0 INTRODUCTION

Mr. Chairman, Members of the Committee, Ladies, and Gentlemen; I am Walter J. Hesse, President of ENTECH, Inc., Dallas, Texas, a high technology solar energy company with products of concentrating photovoltaic systems and high temperature liquid/steam systems, each with a heritage of over ten years. I am also Chairman of the Solar Thermal Power Division of the Solar Energy Industries Association, SEIA, and it is in this role that I address you today.

SEIA appreciates the opportunity to testify on the FY 87 solar programs and budgets. The Solar Thermal Power Division of SEIA consists of more than 30 member companies ... 5 Fortune 500 corporations, several utilities, and more than 2 dozen small business companies. We work with high-temperature (more than 300°F), solar generated steam and apply this steam energy to industrial process applications or use it to generate electricity by means of steam turbines or other types of engines. Thus our division's work concerns high-temperature, high-technology, solar concentrating collectors, high flux receivers, energy process flow control, and prime mover machinery.

Some of our companies have fielded a few significant solar installations, thanks to the combination of federal and state energy tax credits plus a good government R&D program. However, most of our companies' activities are devoted to advanced R&D for improved component efficiencies and lower cost so as to achieve an end product that will be competitive without tax credits in the open market. As a group we believe it is imperative for the solar thermal R&D budget to remain at the $30M level (the average of the last 2 years) if we are to retain a viable technology industrial base.

2.0 INDUSTRY CRITICAL JUNCTURE

The solar thermal power industry is at a critical juncture in its evolution. The DOE R&D budgets for solar thermal power have steadily declined for the last five years FROM $55M in FY 82 to a proposed $15.3M for FY 87, an amount that is really too small to maintain an effective cadre of talent. Table 1 below shows the solar thermal power budget for the last 7 years.

TABLE 1

FY 80 = $143.2M
FY 81 = $138.3M
FY 82 = $ 55.0M
FY 83 = $ 44.5M
FY 84 = $ 43.9M
FY 85 = $ 35.2M
FY 86 = $ 26.9M to $ 25.8M adjusted
FY 87 = $ 15.3M (proposed)

This rapid decline in the R&D budget plus the lapse or termination of solar tax credits has caused many companies to abandon their activities in solar thermal power work. Since 1981, thirty percent of the major companies involved in developing solar thermal technologies have discontinued their research activities in this field. The majority of these are large companies, mostly large diversified manufacturers. Their solar work formed only a small part of their overall operations. The two most common reasons for ceasing activity in solar thermal technologies were the decline of federal funding for research and the diminishing near term marketability of the technology.

3.0 INDUSTRY SURVEY CONCLUSIONS

SEIA has just completed an extensive survey and posture analysis of the solar thermal power industry. The briefing papers of this study are attached as Appendix A. The conclusions reached from the study are most noteworthy and are cited below.

- It is clear that the current soft market for oil and gas dominate the environment in which our companies operate.
- There has been a major decline in the solar thermal industry in the last four years.
- The industry expects the decline to continue because no near-term market is in sight and DOE budgets have continued to fall.
- The industry has invested and is willing to continue to invest private funds in solar thermal research and development because it remains optimistic about the potential of these technologies.

- o Industry believes that a strong federal role remains essential because of falling energy prices and high technical risks in certain areas.

The last item on the above list is the critical one ... industry needs a strong and adequate DOE R&D program. We should take advantage of the relatively "quiet energy period" while low oil prices prevail and perform our R&D to keep the industrial and laboratory teams together. These teams will develop improvements and innovations so as to bring solar energy systems low enough in cost to be competitive when oil prices start rising again.

4.0 THE U.S. NEEDS A STRONG SOLAR INDUSTRY

4.1 Some Key Issues

There are many reasons for developing a strong vibrant solar energy business. The key ones are:

- o Decrease dependency on imported oil with its negative trade balance.
- o Improve our environment with non-polluting solar energy (less smog, CO_2, and other wastes).
- o Create many new jobs ... solar energy business is labor intensive.
- o Allow utilities to build plants in modular form and quickly (not 8 to 15 years for some coal and nuclear plants). LUZ Engineering Co., one of our member companies, installed a 30 MW electric power plant in ten months in 1985.
- o Create exports and help our trade balance ... most developing nations are in great need for non-polluting solar energy, and a healthy U.S. solar industry will generate many affordable export products.

4.2 Solar Thermal Power Is Ideal For Industrial Process Heat

Solar thermal can play an ever increasing roll in meeting the country's industrial heat needs. Applications where solar input is matched to thermal requirements include many industrial process heat applications, such as:

- Heat for batch processing such as canning and food processing,
- Heat for desalination and waste water purification, and
- Industrial cooling for buildings and processes.

The use of solar in these critical applications will help to make our food processing and other industries which use low grade industrial heat, more independent of the volatile world energy supply.

4.3 Solar Thermal Power Is Ideal For Utility Growth

Even though oil prices have dropped in the last two years (the cost of electricity in most places has continued to rise), it is still important to develop alternatives for electric power generation which are not dependent on fossil fuels and large nuclear plants. The solar thermal electric generating option does not increase the pollutant levels in the atmosphere or contribute to atmospheric carbon dioxide and also does not require a safe place to dispose of spent radioactive material. Solar provides a clean, environmentally safe, option for electric power generation. Recent advances in low-cost heliostat and point focus devices, together with higher system performances, have given solar thermal the potential to compete effectively with conventional electric generating capacity. Work on these technologies must be continued so that the utilities can evaluate the plants and their operating characteristics and determine how best to integrate them into the national electric generating mix. The utilities have learned, for example, that solar thermal electric systems with only a minimum of storage, beautifully match their peak loads.

4.4 Solar Thermal Power Can Improve The U.S. Balance Of Payments

Solar thermal is a high technology industry capable of supplying the heat and electricity that a growing world population will require. Many countries around the world, in excellent sunshine areas, desire clean renewable energy. Solar thermal power has the potential of becoming a large-scale export commodity. Should our government and industry not meet the challenge, solar thermal power could become a major import product shifting the balance of trade in the wrong direction.

4.5 Solar Thermal Power Can Improve the United States Economy

Solar thermal technology has the potential to provide two major benefits to the U.S. economy. The first is that jobs will be created in America and these jobs will represent Americans building energy systems for other Americans. The second benefit is that as Americans purchase and utilize solar energy systems, the demand for imported oil decreases and as this occurs, dollars which were leaving the country to pay for imported oil would now stay in the country. Thus, solar energy can help increase the energy available to build the Gross National Product while reducing dollars paid for imported energy.

4.6 Solar Thermal Power Can Improve The United States Energy Image And National Security

The large scale implementation of solar technology which is dependent on the partnership between industry and government for its development will show the rest of the world that the United States is serious about gaining energy independence. Furthermore, it will provide evidence that the U.S. as a free society has chosen an energy option which will not pollute the atmosphere or toxify areas of the planet with high level radioactive waste in order to sustain economic growth. Large scale implementation will also make our communications and energy supply lines difficult to damage. We should always keep in mind, that by sinking a few tankers, an oil supply line can be cut off, and blowing up one strategic nuclear power plant could cripple a major portion of the country. Solar energy would be captured in a distributed way and therefore make individual companies and municipalities far less subject to interruption of energy supplies.

4.7 Solar Thermal Power Can Be Applied To Space Programs

The solar thermal technology will have major applications within National Defense and Space programs. Satellites and space stations of all types, communication, reconnaissance, and observation vehicles must have electric and thermal energy in order to function. This electric and thermal energy will no doubt be generated by solar thermal or photovoltaic systems. Solar thermal technology will be able to play a major role in the energy supply for satellite systems and space stations.

4.8 Solar Thermal Power Has Some Unique Characteristics

Solar electrical energy can be produced by either solar thermal power or, its sister technology, solar photovoltaics. For certain applications, one technology has advantages over the other, so each will be used where the fit is best. Since solar thermal power is generated by concentrators, it yields certain unique characteristics, namely (1) easy storage (merely store the working fluid that is being heated) and (2) attainment of extremely high temperatures, 2000°F to 5000°F or higher for solar engines, solar furnaces, or solar chemical reactions.

5.0 SOLAR THERMAL POWER TECHNOLOGY PROGRESS

Significant accomplishments were achieved in our technology during 1985 in both the federal and private sectors.

5.1 Federal Sponsored Programs

- Completed molten-salt electric experiment (MSEE).
- Completed Vanguard dish-Stirling project, with a record peak efficiency of 31.6% and an all-day efficiency of 25.2%.
- Completed Shenandoah total energy project test and operation phase and transferred facility to Georgia Power Company.
- Completed industrial process heat parabolic trough projects program.
- Selected contractors for small community solar experiments at Osage

City, Kansas and Molokai, Hawaii.

- Awarded innovative dish concentrator and advanced heliostat contracts.
- Completed first year of the cooperative three year (1984-1987) power production phase at 10 MWe Solar One Pilot Plant, Barstow, California.

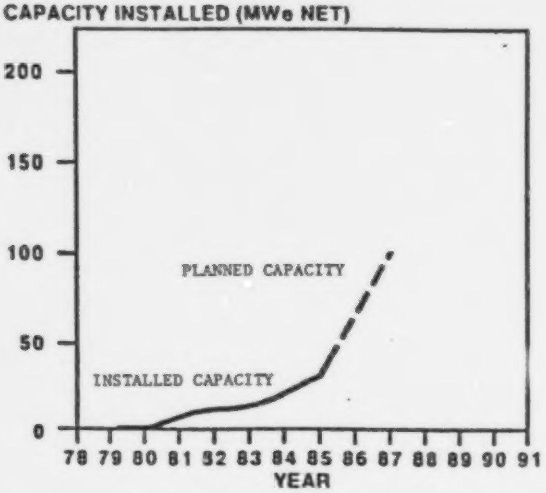
5.2 Private Sector Major Events

- LUZ SEGS I: Initiated operation of 14.7 MWe parabolic trough project at Daggett, California.
- LUZ SEGS II: Installed in only 10 months and started operation of the world's largest solar power plant, 30 MWe, at Daggett, California.
- LaJet Solar Plant 1: Initiated operation of 4.92 MWe parabolic dish project at Warner Springs, California.
- McDonnell Douglas/United Stirling: Initiated prototype limited production of parabolic dish/stirling modules.

By far the most significant event cited above is the LUZ SEGS II solar power plant. In addition to being the world's largest solar power plant to date, it truly is the most significant step to commercialization. LUZ is planning to build two more 30 MWe plants, SEGS III and SEGS IV, prior to mid 1987, when the California solar tax credits expire.

5.3 Domestic Installed Capacity Trend

The chart below shows the domestic solar thermal power electric capacity installed to date and the near future planned capacity.



TOTAL DOMESTIC SOLAR THERMAL ELECTRICITY CAPACITY TREND

The trend line is very impressive, but it should be remembered that 45 MW of the installed capacity and 60 MW of the planned capacity comes from one corporation, namely LUZ. Furthermore, the financing for these solar power plants is made possible by use of the Federal and State Tax Credits, both of which are due to expire (the Federal credits may already be dead) and accelerated depreciation plus PURPA, which ensures that utilities will purchase the power.

The expiration of these favorable tax treatments is a key reason for a continuation of an adequate Federal R&D program ... let's make solar energy cost effective without the favorable tax treatments.

6.0 SUMMARY AND RECOMMENDATIONS

Solar research teams in industry, laboratories, universities, and utilities have evolved over 10 years and they have matured into effective working units with a good network of interaction and communication. Funding from the DOE, through such organizations as Sandia National Laboratories and SERI, have played a major roll in demonstrating the viability of industry's teams. Complementary government laboratory research has accelerated progress. The teams are enthusiastic and dedicated ... they would have to be after being "sifted and consolidated" through a continued budget reduction process since 1980.

The proposed budget recommendation of $15.3 would decimate these teams and many would disappear, as some have already done. It is important to remember that DOE has invested about $1 billion in Solar Energy over the years and that industry has invested an additional $200 to $300 million dollars; thus if the R&D teams disappear, then these major investments will be mothballed.

The Solar Thermal Power Industry 5-Year R&D Plan, which is complementary to and in support of the DOE multiyear R&D plan, calls for $40M per year funding. In the spirit of helping reduce the overall federal deficit, we have restructured the R&D plan to progress at a slower rate at $30M per year (collection technology = $14M, energy conversion technology = $6M, and systems & application technology = $10M).

In conclusion the solar thermal power industry makes the following budget related recommendations:

1. That the R&D funding level be continued at no less than $30M, about the average of the last 2 years funding. (We note that the total DOE budget has increased from $11.9716B in FY 86 to $12.1001B in FY 87, an increase of $128M, and that the proposed solar budgets have been cut in half.)
2. That should there be a tax on imported oil, which the majority of our members support, a portion of it be directed to solar thermal research to enhance the $30M to help assure earlier energy independence.

A REVIEW OF THE SOLAR THERMAL POWER INDUSTRY:

FUTURE OUTLOOK

DEPARTMENT OF ENERGY BRIEFING

JANUARY 27, 1986

CARLO LA PORTA
JEFFRY J. ERICKSON

SOLAR ENERGY INDUSTRIES ASSOCIATION

- GOAL

  TO REPEAT THE 1981 JET PROPULSION LABORATORY SURVEY OF THE SOLAR THERMAL POWER INDUSTRY TO PRESENT THE CURRENT STATUS OF THE INDUSTRY AND COMPARE IT WITH 1981.

- METHODOLOGY

  39 COMPANIES WERE IDENTIFIED AS REPRESENTING THE PREDOMINANT COMPANIES INVOLVED IN THE INDUSTRY. 37 OF THESE WERE INTERVIEWED, EITHER BY PHONE OR IN PERSON. QUESTIONS FROM THE 1981 JPL SURVEY AND NEW QUESTIONS ON TAX CREDITS, MARKETING, AND REASONS FOR LEAVING THE INDUSTRY WERE ASKED.

- DATE

  MOST OF THE INTERVIEWS WERE CONDUCTED OVER A FIVE WEEK PERIOD IN SEPTEMBER AND OCTOBER 1985. INDUSTRY REVIEWS WERE RECEIVED IN EARLY JANUARY 1986.

FINDINGS

Finding: 1 INDUSTRY COMPOSITION

The industry is composed primarily of small companies oriented almost exclusively to solar and large corporations with an interest in solar, but with a diversified base. The companies surveyed have an average of 19 employees working on solar thermal systems. These core companies are supported by five medium and large companies which produce solar components and materials while producing a variety of other products unrelated to solar energy (see Table 1). The vast majority of companies either spend all their R&D budget on solar thermal or they spend less than ten percent.

SOLAR THERMAL COMPANY TYPES

Number of Companies	Type of Company
11	Small solar or mostly solar company
6	Large diversified manufacturer
3	Large A&E or systems integrator
5	Medium and large manufacturer of specialty products (chemicals, engines, coatings, reflective surfaces, etc.)
2	Medium sized, diversified high tech research and manufacturing

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Table 1

SOLAR THERMAL COMPANIES INTERVIEWED
BY TECHNOLOGY

PARABOLIC DISH	PARABOLIC TROUGH	CENTRAL RECEIVER	A&E/SYSTEM INTEGRATOR	MISCELANEOUS
Acurex	Acurex			
Advanco				
Babcock & Wilcox	Babcock & Wilcox	Babcock & Wilcox	Babcock & Wilcox	
Barber-Nichols Engineering				Barber-Nichols Engineering (Rankine)
Bechtel Nat. Inc.	Bechtel Nat. Inc.	Bechtel Nat. Inc.	Bechtel Nat. Inc.	
		Black & Veatch	Black & Veatch	
				Dow Corning Corp. (Fluids, Coatings)
				DSET Laboratories, Inc. (Testing)
Entech	Entech			
		Foster Wheeler Dev. Corp.		
Garrett Turbines				Garrett Turbines (Brayton)
La Jet Energy Co.				
	LUZ			
McDonnell Douglas		McDonnell Douglas	McDonnell Douglas	
Mechanical Technology Inc.				Mechanical Technology Inc. (Stirling)
MTI Solar	MTI Solar	MTI Solar		MTI Solar (Black Chrome)
Olin	Olin	Olin		Olin (Chemicals)
Power Kinetics, Inc.				
Rockwell International		Rockwell International	Rockwell International	
Science Applications Int.	Science Applications Int.	Science Applications Int.		
Sanders Associates, Inc.				Sanders Associates, Inc. (Brayton)
Solar Kinetics, Inc.	Solar Kinetics, Inc.	Solar Kinetics, Inc.		
Solar Steam				
		Solar Power Engineering Co.		
Stearns-Catalytic Eng.	Stearns-Catalytic Eng.	Stearns-Catalytic Eng.	Stearns-Catalytic Eng.	
3-M	3-M	3-M		3-M (Reflective & Absorbine Materials)
United Stirling				United Stirling (Stirling)
21	11	13	6	10

COMPANIES EXITING THE BUSINESS SINCE 1981

PARABOLIC DISH	PARABOLIC TROUGH	CENTRAL RECEIVER	A&E/SYSTEMS INTEGRATOR	MISCELANEOUS
		Arco Pwr. Systems		
Boeing Engineering	Boeing Engineering	Boeing Engineering	Boeing Engineering	
Ford Aerospace			Ford Aerospace	Ford Aerospace (Stirling, Rankine)
	General Atomic		General Atomic	
Honeywell, Inc. TSC	Honeywell, Inc. TSC	Honeywell, Inc. TSC		
Jacobs-Del Solar Systems	Jacobs-Del Solar Systems			
		Martin Marietta	Martin Marietta	
		Nielsen Engineering	Nielsen Engineering	
		Westinghouse Energy Systems	Westinghouse Energy Systems	
Wyle Laboratories	Wyle Laboratories			Wyle Laboratories (Testing)
5	5	6	6	2

Finding: 2

COMPANIES OUT OF THE FIELD

Since 1981, thirty percent of the major companies involved in developing solar thermal technologies have discontinued their research activities in this field. The majority of these are large companies, mostly large diversified manufacturers. Their solar work formed only a small part of their overall operations. The two most common reasons for ceasing activity in solar thermal technologies were the decline of federal funding for research and the diminishing near term marketability of the technology. Lack of funds and signs that a market would be very slow in developing led these companies to redirect their attention and funds to other topics.

Finding: 3

INDUSTRY ACTIVITIES

The makeup of the industry has changed significantly. The percent of companies providing engineering services has dropped since 1981, from 74 percent to 48 percent while the percent of companies providing subsystems and components has risen, from 44 percent to 63 percent. There are fewer companies offering turnkey systems, but the percent of the industry remained unchanged (26 percent). Similarly, there are fewer companies doing R&D work for the government, but the percent of the industry did not change significantly (1981: 80 percent; 1985: 74 percent).

Finding: 4

PROGRAM GUIDANCE

When asked how much longer the DOE solar thermal program should continue, the average response was 17 years -- a significant increase over the 10.8 years in 1981 -- indicating that the industry generally believes the federal program should continue well into the 1990s and perhaps into the 21st Century. When asked what the federal budget for solar thermal systems should be, the average value was $57 million. In 1981, the industry average was $171.3 million.

Finding: 5

UTILITY OVERCAPACITY

One of the most important barriers to the solar thermal industry's success is utility overcapacity. Utilities, by and large, are not interested in new generating technologies, especially expensive, unproven ones. Even some utilities that do not have enough capacity are not interested in new generating technologies since they can buy power very cheaply from neighbors suffering from overcapacity. Thus in many areas the solar thermal industry must compete with existing sources of cheap power, not expensive new generating plants.

Finding: 6

CENTRAL RECEIVER NEEDS

Central receiver companies believe that their technologies could be marketable within the next five years but do not expect to see significant market development without increasing energy prices or increased support from the Department of Energy or both. Specifically, most companies believe that the risks for supporting commercial-scale plants, or even a significant scale-up of Solar One, are too high for the private sector to undertake alone at present. Without support by DOE the industry believes that the market will not develop until energy prices rise enough to balance the benefits with the risks -- and that may take 10 to 20 years or more. The central receiver companies exhibited great confidence in their technology and generally felt that no insurmountable technical barriers stand in their way. However they strongly believe that the industry needs at least one large new central receiver project to demonstrate new systems and designs on a large scale before they will be able to convince investors and utilities to invest in building the first commercial plants.

Finding: 7

DISTRIBUTED RECEIVER COMPANY NEEDS

Twenty-one companies are working on point focus distributed receiver systems or components. Eleven are working on line focus technologies. Point focus system manufacturers are generally optimistic about their technology and believe the market will develop and grow fairly rapidly if they receive federal support and incentives. Without such support they either expect to grow very slowly, expect to sell little or no systems while waiting, or expect to go out of business. Several believe that a three year credit of 25 percent would be sufficient to bring them to the point of self-sufficiency -- competitive in the present market without subsidies. The only company successfully marketing technology is Luz Engineering. The American companies have ceased any aggressive marketing.

Finding 8

INDUSTRY INVESTMENTS

On average, each company in the solar thermal power industry has made a cumulative investment of approximately $4.7 million of their own funds for advancing the technology over a period averaging 10 years. Some companies invested significantly more with the highest estimate at $35 million. If the three largest investors are eliminated from the equation, the industry average is $1.4 million. Cumulative federal R&D funding for these same companies averaged $9.9 million per company over ten years, or $4.6 million without the two largest companies. Comparing these figures makes it evident that the industry is undertaking significant cost sharing of solar thermal R&D -- between 30 and 50 percent of federal funding.

Finding: 9

FEDERAL R&D SUPPORT NEEDED

Interest in federally supported research increased in all areas. Testing prototypes and developing subsystems and components were identified as critically important and 96 percent of the industry believes federal research support is necessary in these areas. Interest in basic research increased 33 percent since 1981.

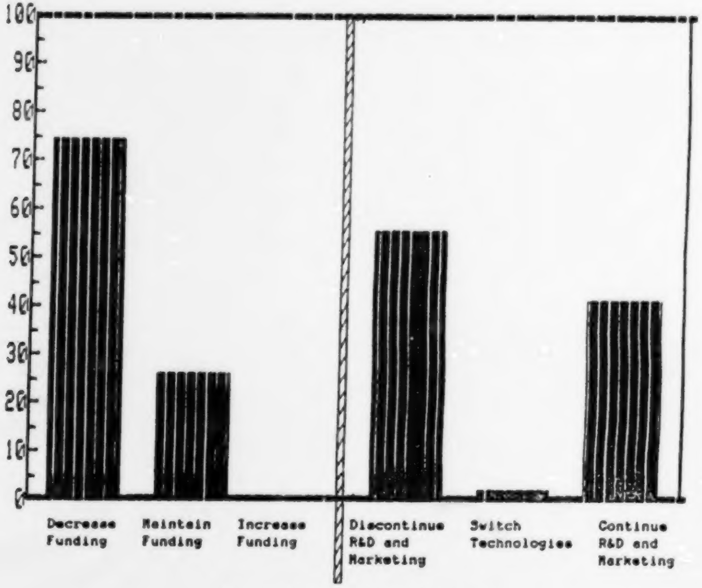
TYPES OF FEDERAL R&D SUPPORT NEEDED

Type of Support	% Yes 1985	%Yes 1981	%Change
Testing prototypes	96	92	+4
Develop subsystems and components	96	89	+7
Full-scale system tests	83	83	+0
Develop conceptual designs	74	62	+12
Basic Research	77	44	+33

Finding 10

INDUSTRY PLANS FOR THE FUTURE

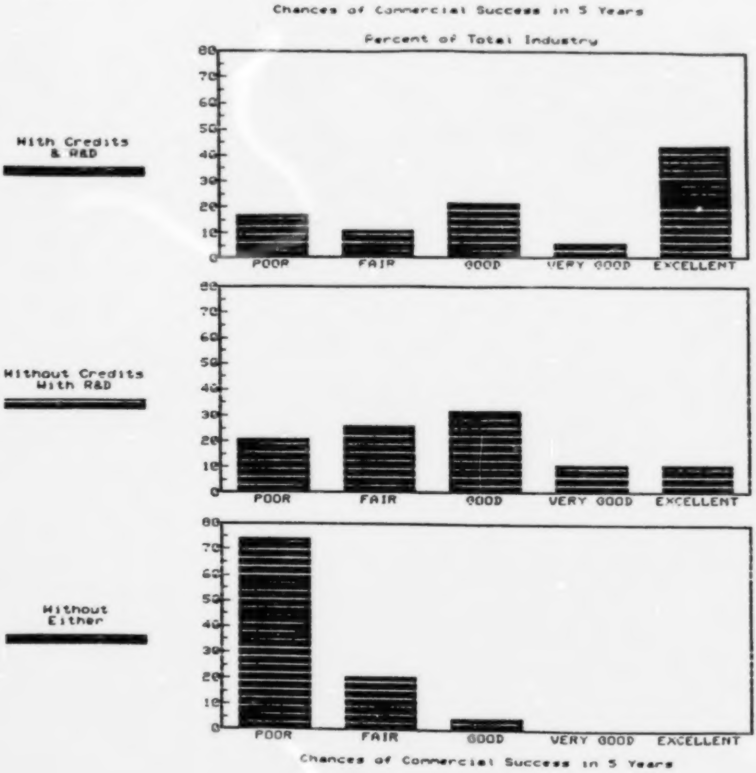
If DOE Funding Discontinued



Percent of Respondents

Finding 11

IMPACT OF TAX CREDITS AND FEDERAL R&D



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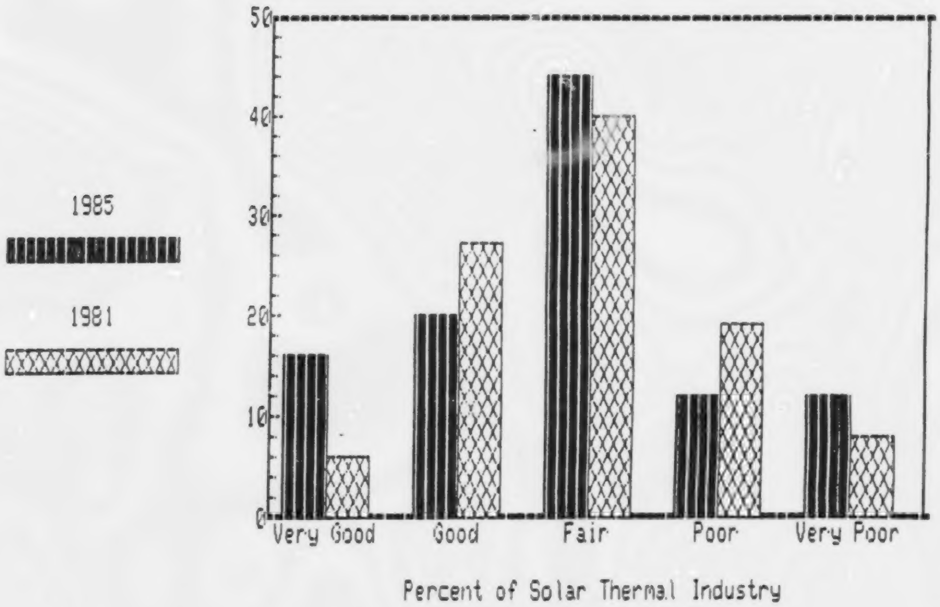
Finding 12

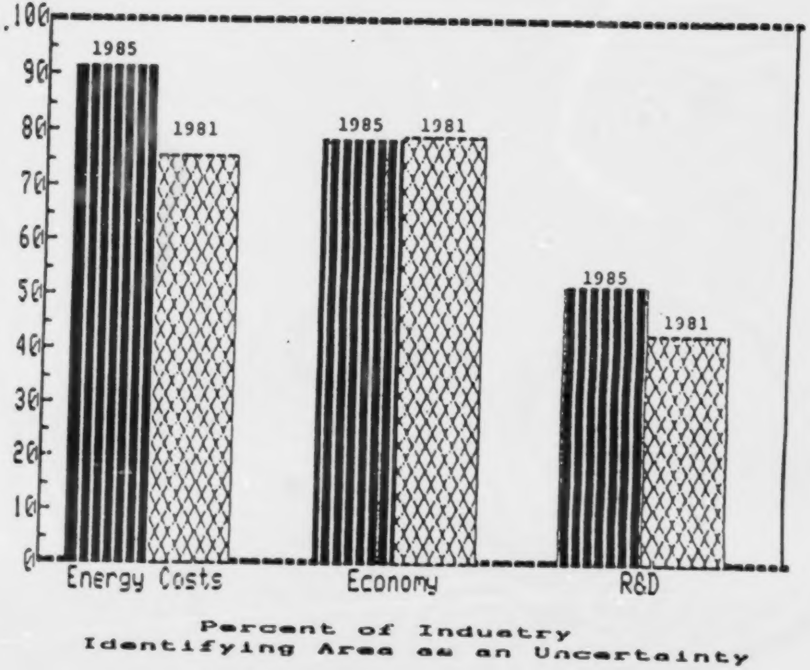
EVALUATION OF THE DOE PROGRAM



Finding 13

UNCERTAINTIES

Many of the companies stated that their business is more dependent on energy prices than on tax credits and federal support. Most do not expect energy prices to climb significantly within the next 10 years and thus do not expect business to be very good without help in some form. Of the companies that are actively marketing products or services to commercial users, 56 percent (nine companies) expect to make a profit this year and 44 percent (seven companies) do not. Many of the other companies that are not, at present, marketing to commercial users don't expect to make a profit until energy prices rise significantly, whenever that may be. Ninety-one percent of the companies responding to the question (21 companies) believe that the cost of competing energy sources creates an uncertainty for making commercially viable solar thermal products, a significant increase over 1981.



CONCLUSIONS

- It is clear that the current soft market for oil and gas dominate the environment in which these companies operate.

- There has been a major decline in the solar thermal industry in the last four years.

- The industry expects the decline to continue because no near-term market is in sight and DOE budgets have continued to fall.

- The industry has invested and is willing to continue to invest private funds in solar thermal research and development because it remains optimistic about the potential of these technologies.

- Industry believes that a strong federal role remains essential because of falling energy prices and high technical risks in certain areas.

STATEMENT OF ROGER G. LITTLE, SPIRE CORP., BEDFORD, MA

Mr. LITTLE. Mr. Chairman, my full testimony is submitted. I would also like to submit some letters from industry which support some of the comments I will make.

I will quickly review the highlights of my testimony.

As you know, photovoltaics is a semiconductor-based technology which converts sunlight to electricity. Photovoltaics has great promise, not only for contributing to America's energy needs, but also as a major export commodity, a high-technology product.

The photovoltaic industry, working with the DOE, has made a lot of progress. Faced with the budget presented to us, which is $20 million versus the $45 million from last year, it will have a tremendous impact upon the industry. We will lose momentum. We will lose our leadership position in the world markets, and we'll throw away perhaps as much as the $500 million which has thus far been invested by DOE in this research project.

The Japanese are now capitalizing on our investments. They are taking our basic research technologies and bringing them to the market.

What I wanted to do was briefly tell you what we're trying to do, the progress we've made, and what the effects of the cutbacks would be; and then to make a strong recommendation that the budget continue at the same level that it has been at for the last couple of years, which is this $45 million level.

We know that photovoltaics is ideal for utility growth. It was determined by the Office of Technology Assessment to show that it could be added in small increments, flexibly and gradually. However, it's also a very important export market. It's like electronics; it's a high-technology export industry. The Japanese budget now is going to be greater than ours in fiscal year 1987. The Japanese new energy development authority has a budget of $35.4 million scheduled for 1987 versus the OMB recommendation of $20 million. We can't allow our leadership that we have built for so long to be dissipated and be taken away by the Japanese.

Last week I received a letter from a new Japanese company moving into the United States, a company called C-Tech, establishing themselves in California. On Monday, we had MITI visiting the Lincoln Laboratory MIT facility to look at photovoltaic systems that have been developed for residential purposes, looking at a cadaver left over from previous budget cuts.

Three quarters of the world's population doesn't have electricity, so photovoltaics is ideal for places like Central America, India, and the People's Republic of China. These markets are being targeted by the Japanese and the Europeans.

Congressman Mavroules had legislation passed which says the military must buy photovoltaics if it's deemed cost-effective. This legislation is just identifying as many as 40 different applications. We certainly want the American industry to be there to fulfill those procurement requirements when they are clearly identified and the procurements take place.

American Embassies all over the world would benefit from more secured facilities with the use of photovoltaics for communications and electricity.

Where are we? Over the past 10 years, we've made a lot of progress as an industry. We've worked in partnership with the Department of Energy, Government labs, and universities. We developed plans; we stuck to the plans. We've made significant technical progress, and we are moving toward the marketplace. We have achieved things like 15 percent efficient modules that last more than 20 years, that have the potential to be manufactured at much lower cost. A measure of progress is that costs have gone from $50 a watt to $5 a watt over this period of time, but we need to get down another factor of three or so. To do this, we need aggressive research and we need help from DOE.

The industry is about $150 million a year. That is not enough to sustain the kind of budgets we need to bring the costs down. And $20 million is not going to do it; we need the $45 million to bring the costs of our product down to address these larger markets.

The effect of the budget reductions will be to destroy the momentum that we have as an industry, as a research and development community. We'll lose our momentum in innovation. We could lose our leadership position in a hotly contested world market, and we could lose our $500 million R&D investment.

So in summary, ourcommunity—our photovoltaics research and development community—has been beaten down from $150 million to less than $50 million in 5 years, while other nations' budgets have increased. Further cuts will jeopardize the industry. We strongly recommend that no further cuts be made, and that we sustain that $45 million a year level.

Thank you very much.

[The prepared statement of Mr. Little follows:]

TESTIMONY BEFORE HOUSE SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

February 27, 1986

PHOTOVOLTAIC INDUSTRY RESEARCH NEEDS

by

Roger G. Little
President
Spire Corporation
Bedford, MA 01730

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1.0 INTRODUCTION

The technology for the direct conversion of sunlight to electricity, photovoltaics, continues to hold great promise for the future of America. Even as this promise becomes more clear, the American photovoltaic community is faced with the potential of significant Department of Energy research budget reductions. The resulting impact could cause our nation to lose momentum and the preeminent worldwide position we have obtained with photovoltaics technology.

The purpose of this letter is to state briefly and concisely:

(1) the opportunities before us;

(2) the progress that the photovoltaic industry has made in partnership with the Department of Energy;

(3) the likely effects on the photovoltaic community of additional significant research budget cuts at this time; and

(4) the need for the United States and its Department of Energy to continue their commitment to the advancement of the technology as we move toward large scale commercialization.

2.0 PHOTOVOLTAICS IS MUCH MORE THAN AN ENERGY OPTION

It is a renewable energy source that is unequaled in terms of benign environmental impact and broad application.

2.1 Photovoltaics is Ideal for Utility Growth

Although oil prices have dropped over the past two years, electricity prices have not. Many U.S. utilities are at a critical crossroad as they confront an uncertain future for electricity demand. Large conventional capacity additions required for their scale economies pose considerable financial risks to the industry. Photovoltaic technology, however, has proven itself to be ideal for adding dispatchable generating capacity in the required incremental quantity. The fact that photovoltaic energy production has minimum environmental impact is an important attribute for utilities, their regulatory commissions, and concerned citizens.

2.2 Photovoltaics Can Improve the Balance of Payments

Photovoltaics is a high technology export industry. The demand for electricity in developing countries, which lack established utility distribution grids, gives photovoltaics the potential of becoming a large-scale export commodity. However, should our government and industry not meet the challenge, photovoltaics as a successful and mature technology could become a major import product. Although America now holds a leadership position in the technology, the Japanese are aggressively pursuing commercialization of America's research base. As research budgets have been reduced, many American companies have sold the only product they have market-ready, the know-how itself, for survival. We cannot allow our investment in this technology to be dissipated.

2.3 Photovoltaics Can Reduce U.S. Reliance on Foreign Energy Sources

Photovoltaics can reduce our nation's dependence on foreign oil imports. Photovoltaic production requires no off-shore components, and once installed, photovoltaic arrays require no fuel and little maintanence, thus making such power sources immune to fluctuating oil prices. The present relative calm is the ideal time to carry forward research on this technology, as Japan and other nations are now doing.

2.4 Photovoltaics Can Contribute to the World Standard of Living

Photovoltaically powered water pumps, medical refrigeration, electric lights and television receivers have been widely deployed. These stand alone systems have been used to educate, improve the health, raise the standard of living, and improve the quality of life for people throughout the world including the United States. Several foreign nations - notably Japan, Germany and France - have listened to the requests of developing countries for access to this appropriate technology and routinely supply photovoltaic equipment as part of foreign aid programs.

2.5 Photovoltaics Can Make Our Military Stronger

Energy self-sufficiency is a must for our military. Portable photovoltaic power systems are being used for communications and field installation in place of diesel oil generators. The Department of Defense is actively working on more applications - not because of legislative mandate but because photovoltaics fills a real need for quiet, reliable, maintenance-free power. Photovoltaics will be used in increasing quantity by the military, provided the legislative mandate to use life-cycle costing in economic decisions is not abandoned because of budget pressure to lower initial cost. American embassies throughout the world would benefit greatly from photovoltaic energy to ensure continuous self-contained power for lighting and communications.

3.0 PHOTOVOLTAIC TECHNOLOGY PROGRESS

The photovoltaic community began planning the research program necessary to achieve significant manufacturing cost reductions more than 10 years ago. More recently, the photovoltaic industry and research community, working closely with DOE, universities, government laboratories, and electric utilities, has contributed to the development of the DOE Five-Year Research Plan. The Plan's ultimate objective is a reduction in the price of electricity generated by photovoltaics. The Plan identifies the research needed to establish the technology base for large scale commercialization of photovoltaics. Industry, universities, government laboratories, and electric utilities have adopted this plan and are now making exceptional progress toward these common goals, including:

(1) Efficiency - photovoltaic modules will be produced with greater than 15% conversion of sunlight to electricity;

(2) Endurance - photovoltaic modules will operate reliably for more than 20 years;

(3) Manufacturability - the feasibility of low cost production is now being established.

As a demonstrated measure of progress, the industry's manufacturing cost, reflected in product price, has dropped more than an order of magnitude since terrestrial photovoltaic research initiatives began 10 years ago. However, cost must be reduced by at least another factor of five to have large-scale utility impact. This reduction will only come through further aggressive research.

4.0 PHOTOVOLTAIC INDUSTRY COMMERCIALIZATION STATUS

Although the PV industry has grown at a greater than 40% compound growth rate over the past ten years, it is still very small. Worldwide revenues for 1985 are estimated to be only $150 million. U.S. private industry currently has approximately 50% of the world market and is investing approximately $60M/yr in research and development. Industry alone cannot afford to support the research base necessary to bring the technology to the next cost/performance plateau. Continuing government help is mandatory to develop the scientific foundations upon which a large-scale industry can grow.

5.0 EFFECT OF PV BUDGET REDUCTIONS

After a decade of building, industrial research, university and national laboratory teams have achieved critical mass. They are enthusiastic, dedicated, and making progress ahead of the timetable. Funding from DOE, through such organizations as SERI, has played a major role in achieving this rate of progress. Complementary government laboratory research has accelerated progress. Overall program coordination has identified common goals. Reduction in federal support will disrupt these unique dedicated research teams halfway through the program. The momentum we have gained may never be recovered and our international leadership position will be lost.

6.0 SUMMARY AND RECOMMENDATIONS

Since 1982, the American photovoltaic research community has experienced budget reductions of greater than two-thirds, from $150M to $50M, while the budgets of Japan and other nations have increased. The DOE Five-Year Research Plan initiated in 1983 was developed on the basis of a budget of approximately $60M per year, which has been more than matched by industrial research funding. Much progress has been made at that level of funding toward establishing the technology base necessary for large scale commercialization of photovoltaics, but much remains to be done. Further budget reductions, coupled with the loss of energy tax credits, will jeopardize the entire industry and the promise of photovoltaics may go unfulfilled.

Based upon these considerations, the photovoltaic community recommends that DOE photovoltaic research funding be continued at a level no lower than that of the last two years, $45M, to sustain the research momentum for this important electric technology. The detailed recommended budget elements are contained in Table I. By providing the necessary research base, the DOE insures that American industry will be able to fulfill photovoltaic technology's promise of both significant contribution to the U.S. energy needs, and to development of a large-scale high technology export industry.

TABLE I

FY 87
BUDGET RECOMMENDATIONS ($ Millions)

1.	Single Junction Thin Films	
	a. a-Si	4.0
	b. High efficiency concepts	4.8
	c. Advanced thin films	6.0
	d. Deposition research	2.0
		$16.8
2.	Multi Junction Concepts	
	a. a-Si	3.8
	b. High efficiency	3.9
		$ 7.7
3.	Innovative Concepts	
	a. New idea	2.0
	b. University Program	3.0
	c. Thin Film encapsulation	1.5
	d. Institutional Issues	1.3
		$ 7.8
4.	Advanced Film Sheet	$ 1.0
5.	Flat Plate Collector	-0-
6.	Concentrator Collector	$ 3.5
7.	Module Reliability	
	a. Thin film	1.5
	b. Concentrator	2.5
		$ 4.0
8.	Army & BOS Development	-0-
9.	Systems experiments	
	a. Utility interface	1.0
	b. Critical components	1.0
	c. Performance measurements	0.5
		$ 2.5
10.	Technology Transfer	$ 1.2
11.	Capital Equipment	$ 2.0
	Total	$46.5

SOLAREX
Corporation

February 26, 1986

The Honorable Don Fuqua
2269 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

There is significant concern within the United States photovoltaic industry that the proposed 1987 federal budget for photovoltaics is below a credible level to sustain a successful, nationally focused, development program. The $20.6 million dollar effort represents the lowest federal budget for this technology, in terms of real 1975 dollars since 1976. It also represents a lack of understanding and/or interest by the budget formulating officers of the impact that this level of funding will have upon the national photovoltaics effort. Photovoltaics has been shown to be a technology of near and long term strategic importance to the United States and it is in the interest of the government to insure that the focus of this technology stay within the boundaries of the United States. The Japanese, particularly have recognized the value of this resource and would like to gain this leadership. It has been reported that their New Energy Development Organization (NEDO) alone, has planned for a 1987 photovoltaics budget of $35.1 million dollars, 70% more than the US DOE budget.

It may be important to stress here the success realized by the US national photovoltaic effort. In 1973 at the time the present origins of the program were established, photovoltaics for space was the only industry except for a few hundred watts which were produced for terrestrial applications from reject space solar cells. These solar cell modules were sold for greater than $50.00 per watt. In 1985 the sale of photovoltaics is measured in megawatts and prices of less than $6.00/watt are commonly realized. (This is less than $3.00/watt when placed in the context of constant 1973 dollars.) The potential for even lower cost is quite good and the national and international needs and markets for these products are of major importance.

. . . . more

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The Honorable Don Fuqua
Page Two
February 26, 1986

Solarex recognizes the important role the US government programs have played in fostering photovoltaic development. Because of DOE support, Solarex has been able to accelerate the development of such new products as its advanced semicrystalline solar cells (a joint program with JPL) and most recently in its thin film solar cells (a joint program with Solar Energy Research Institute). These organizations have been a credit to the national advanced energy development programs. The loss of all or part of these organizations from the U.S. energy development effort is viewed as a loss of a national resource; a resource which will be difficult to replace. As any organization focused into this high tech field of PV recognizes, it takes time and engineers to make an effective, contributing team. The proposed FY87 budget demonstrates a lack of support for PV and sends a message for the future that will strongly inhibit the attraction of better technical personnel into the federal government's PV operations and laboratories.

It is hoped that this letter will help gain the support of the US Congress to temper the deleterious effects of the proposed FY87 budget. Some tightening of the belt is acceptable but a decimation of the PV program is contrary to the interest of the United States.

Sincerely,

SOLAREX CORPORATION

John V. Goldsmith

John V. Goldsmith
Vice President

JVG/ch

Mr. SKLAR. As a group, we'd like to thank this committee and the chairman for always supporting solar energy as a part of the energy mix. We know that a lot of our programs would not have been around without your interest and support, and thank you for having us here.

Mr. FUQUA. Thank you.

Let me toss out the first question. Maybe all of you or one of you want to answer it, but you were here earlier when we talked about the cooperative R&D venture when the Secretary was here. And, of course, we realize it lacks definition and substance at the present time, but what inducements would be necessary to involve the solar energy industry in some cost-sharing programs with DOE to translate some of your basic as well as applied into commercial projects?

Mr. GORIN. I'm not sure, Mr. Chairman, that it's inducements that are the problem. The problem is, it's an industry that is very small and, as you've heard these gentlemen testify today, has not had an opportunity to develop the capital resources that that kind of a program really demands to significantly replace what has been the practice over the last few years. I think that if the industry were in a different posture at this time, they would embrace that concept very well. It is a valid concept. It's just simply something that we don't feel at this time is a practical approach for this particular industry.

Mr. SKLAR. To add to that, and I think we all have strong feelings against it, is that we are such a young industry; we have not been around the 40 years like the microelectronics and computer industries have been around. And, frankly, we have not sustained those kinds of profits to be able to put money into something like that.

Another 10 years down the road, I think we could start talking.

Mr. FUQUA. Well, could it be something like through the Association, where then you bring in some people?

Mr. GORIN. We have certainly talked about that, and if we thought we could muster the resources to do it, I think we would be interested in doing something like that. I have looked into R&D partnerships that have been promoted by the Department of Commerce over the last few years, and it is a concept that I think someday will have great validity for this industry.

Mr. FUQUA. Dr. Hesse.

Mr. HESSE. You know, the industry—as I indicated in my testimony—has invested a lot of money, between 20 and 30 cents per dollar from DOE. Now, it's generally been done on specific projects instead of having a pool of companies all get together. And we continue to be willing to invest on specific projects.

I have a wonderful example. Last year, the city of Austin, together with 3M Co., each agreed to cost-share some money for a photovoltaic project with DOE. It was put in the law by Congressman Jake Pickle, and it's now one of those things on the deferral list. There's an opportunity to do what OMB wants to do, and it's already being deferred.

But the industry is willing to invest, and we will continue to do that.

Mr. **Little**. In the photovoltaics community, there are vehicles now which are similar to this but not called this, namely, cost-share programs when technology appears to be ready to bring to the marketplace. So there's heavy cost-sharing. If you want to participate, your company has to step up as a serious contender, and that's not unlike a cooperative R&D venture except that it does discriminate toward those technologies which are market ready, unlike the way I read the present recommendation.

Mr. **Fuqua**. Mr. Little, what are some of the principal needs of the photovoltaic industry and what types of Federal R&D support are necessary?

Mr. **Little**. The Federal program has done much to help to identify what technologies are going to be the most successful. Now, the programs that we need to continue are basic research and development, which is of a high risk nature.

Mr. **Fuqua**. That's going on at SERI?

Mr. **Little**. It's going on principally at SERI.

Then, as the technologies appear to go over certain technical hurdles, beginning to address the marketplace, cost-share type research needs to be pursued to bring them into the marketplace. This is ongoing also at SERI.

And then, finally, a monitoring of the progress we've made in the communication of the photovoltaic technology to the world and to the potential users overseas is of use.

Mr. **Fuqua**. And how much longer do you think this will be necessary?

Mr. **Little**. I think it's—a basic program at this level is necessary for a considerable period of time; you know, at least 5 years. You're talking energy, now, and it takes a long time to move energy into the commercial marketplace. I think that to expect short-term solutions is not what we should do with energy and photovoltaics. I think it will evolve and will get there, and it's worth fighting for and it's worth the commitment.

Mr. **Fuqua**. Dr. Hesse, you mentioned the Barstow project, or Solar-One. It's my understanding that there are some utilities that are formulating—or attempting to formulate—some plans for that facility. Does it appear that their reports are going to be too late to support the continuation of that project? And what would your recommendations be for that project?

Mr. **Hesse**. Barstow-One right now is under a test program. It's a 3-year test program which is currently scheduled to be completed in August 1987. That costs DOE about $1 million a year. In addition, there are three study teams, led by utilities, that are going to take a look at the central receiver concept, using Barstow or Solar-One as the basepoint and going beyond. They're looking at different kinds of working fluids like salts and other techniques that will improve the power plant.

Frankly, if the $15 million remains, the continuation of running Barstow-One has got to be a very low priority. But there are other consequences. You know, it's owned by DOE and it's on Southern Cal Edison property, and it may end up costing more to not take any more data or shut it down.

Mr. **Fuqua**. At one time they were talking about using it to improve the heat storage as a test bed for that.

Mr. **Hesse**. Right.

Mr. **Fuqua**. I think that was last year.

Mr. **Hesse**. Right. I believe the majority of our members would prefer that that type of testing and work be conducted at the Sandia Laboratories, at the CRTF, because it's in place; they have a team down there; they have many other related test activities that go with that. So the consensus would be to continue that type of work down there.

Mr. **Fuqua**. I'm going to ask myself permission to ask one more question.

Dave, what, in your opinion, are some of the impediments that might prevent the line item for SERI?

Mr. **Gorin**. The impediments for preventing?

Mr. **Fuqua**. What problems we'll run into doing that.

Mr. **Gorin**. I don't think you should run into any problems doing that. I think it's something that ought to be done. It's a large enough institution that it ought to be identified individually, and it's important for you and the Members of Congress to know exactly how much money is being expended by a very, very important national lab. I don't see that there should be an impediment.

Mr. **Sklar**. If I can add to that, since it is consistent with the Department of Energy's approach to consolidate research at SERI, and only use now the other national labs for specific projects where they have particular expertise, then we felt, as an industry, it's about time to come clean and become more accountable and have more oversight. And one way to do that, instead of tithing different budgets and different line items for SERI, is just to have SERI out front. We will make that case to the appropriations committees as well, but we felt that this committee, which has supported SERI and its programs for so long, I think it's consistent with your approach to do that. I do not see we would have any problems.

Mr. **Fuqua**. Dr. Hesse, one more, and this will be your final one.

In the solar thermal program, as I look at it in the 1987 budget, it's a close-out budget——

Mr. **Hesse**. I agree with you, sir.

Mr. **Fuqua**. It's closing the doors. How much longer do you think that program should continue?

Mr. **Hesse**. I realize that we may be back in the situation—and I don't remember who it was; I think it was Daniel Webster or somebody—proposed that we close the Patent Office because everything that needed to be invented had already been invented. [Laughter.]

Mr. **Fuqua**. I don't think we need to be put in that situation, but how far along do we need to go with Government support in solar thermal?

Mr. **Hesse**. In my mind, energy resources and energy options are so important to our country that this should be an ongoing, continued effort, far into the future, as long as we have a Department of Energy. We're still doing fossil energy research and development.

Mr. **Fuqua**. Right. It's been around a long time.

Mr. **Hesse**. Been around a long time. And the same thing is true for all these solar and renewable activities.

Mr. **Fuqua**. Thank you.

Mr. Slaughter.

Mr. **Slaughter**. No questions, Mr. Chairman.

Mr. Fuqua. Mr. Walgren.

Mr. Walgren. No questions, Mr. Chairman.

Mr. Fuqua. Thank you very much, gentlemen, for being here. We appreciate your contributions this morning.

[Additional questions and answers follow:]

SEIA

SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 503 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036 (202) 483-622

March 10, 1986

The Honorable Don Fuqua
Chairman
Committee on Science & Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

In response to your letter of February 28, 1986 following up on our testimony before the Subcommittee on Energy Development and Applications, I am pleased to submit the enclosed responses to your questions and the following clarifying comments.

The thrust of the hearing was to solicit industry viewpoints concerning program priorities and possible cuts in order to provide guidance to the Subcommittee. The solar industry stated that we do not believe the solar budget can withstand any major cuts and clearly the cuts should not be greater than any other part of the Department of Energy's budget.

Two major suggestions included in our testimony could make significant overall ckuts without endangering the quality of the DoE program. First, the Congress should set aside administrative/management costs in its own line item. Second, the conservation and solar buildings programs should be merged and include the same program goals as the present DoE solar buildings program. Both moves alone would almost meet the 15% budget savings that the Subcommittee is seeking.

Finally, demonstration programs such as Barstow that do not have a market-oriented benefit should not be funded. With declining funding, the Barstow Solar One program should not be continued if it causes other more useful programs to be sacrificed. If funding can be maintained for solar thermal programs, than Barstow should be maintained as well.

The Honorable Don Fuqua
March 10, 1986
page 2

Attached are SEIA's answers to your questions and a copy of a letter to Secretary of Energy John Herrington which I referred to in my presentation to your committee. Please feel free to contact me or our Director of Government Relations, Mr. Scott Sklar, if you need further information.

Thank you for the opportunity to appear before your committee.

Sincerely,

David Gorin

David Gorin
Executive Vice President

SOLAR ENERGY INDUSTRIES ASSOCIATION

QUESTIONS FROM CHAIRMAN DON FUQUA
RESPONSES FROM THE SOLAR ENERGY INDUSTRIES ASSOCIATION

1. How would you plan, if given the resources, to expand the National Appropriate Technology Assistance Service?

NATAS has been a useful information source and technical referral source in support of the solar industry. It could be expanded and made more useful if funded sufficiently so that it could provide industry information geared to the consumer to help them make more informed purchasing decisions. (The industry has no way of reaching the consumer with this information). NATAS would be a useful vehicle for assisting in developing public awareness of renewables and increasing the public's knowledge of this technology. NATAS could be a useful vehicle in providing referrals to consumers who own "orphan" solar systems, i.e. those who bought systems from companies no longer in business and who require warrenty service. We also suggest merging the CARIERS and NATAS programs into one program so that a synergy is created by having one central program.

2. Please suggest language which directs the Department of Energy to carry out programs for effective transfer of federal research to industry. What would be the cost of such a directive compared to the funds provided in the FY 1986 budget?

Federal research facilities receiving funds for solar energy research shall set aside no less than 1% of their overall funding for the purpose of supporting programs that transfert the information resulting from the research to the private sector. The federal laboratories shall work with existing industry groups to develop ongoing and timely programs to accomplish this purpose. (Since funding would come from the budgeted research dollars, there would be no increase in costs from the present level of activities.

3. You mentioned that the International Solar Energy Program has supported the CORECT process, a federally-mandated interagency coordinating group to promote solar and renewable product exports. What specific help has this been to the industry? Can you provide us with specific examples?

CORECT has promoted the face to face meetings of federal officials with responsibility for export programs for the specific purpose of designing programs to assist the solar industry. The face to face contact has substantially helped the solar industry receive a more positive and responsive attitude from the federal officials involved. Some of the subcommittees of this CORECT group working the multi-national development organizations have been useful in that they are compiling information that will be invaluable for the industry and the federal agencies. Compiling and providing authoritative information (for example, areas of greatest concentration of diesel electric generating systems sales) will certainly aid the US industry in the competitive international environment.

SEIA

LAR ENERGY INDUSTRIES ASSOCIATION Suite 503 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036 (202) 483-6225

December 24, 1985

The Honorable John Herrington
U.S. Department of Energy
Washington, D.C. 20585

Dear Secretary Herrington:

We have been advised by the Office of Management & Budget staff that they desire to change the U.S. Department of Energy R&D program through a radical new technique known as cooperative R&D. The technique would be implemented by various solar industry firms jointly contributing R&D funds to the DOE budget and then sharing the R&D results with each other. OMB staff also advised us on the proposed passbacks to the solar program.

The role model that OMB uses to justify this concept is the Micro-electronic and Computer Technology Corperation (MCC) based in Austin, Texas. MCC is sponsored by a large number of electronic corporations. SEIA is opposed to this concept because the solar industry is too young and small to make this plan workable. The key reasons for our reservations are listed below:

1. The solar industry and the federal laboratories are functioning well together and are making significant progress. A dramatic change as proposed by OMB will take several years to implement and cause the solar industry to lose precious time in our race with Japan and other competitor nations.

2. The solar industry is relatively new and many firms have developed patented and proprietary items that must be protected. Technology is changing every day and there is a fierce competition in the marketplace.

3. The solar industry does not have the experience and financial strength to support such a concept. Again, our industry is new and in many cases consists of small businesses that do not have the necessary investment capabilities. Over 90% of the solar industry has been in existance since 1977 in contrast to the MCC companies that have been in existance 30 years or more.

4. The MCC idea was organized around a very mature industry and it may succeed. But it will take several years to measure the true results of this project. Attempts to copy it are very premature.

NERGY INDUSTRIES ASSOCIATION

SEIA supports the continuation of the current U.S. Department of Energy solar R&D program. It is important to continue our R&D efforts on te same "track" and not make a major change in format at this time when budget reductions are being imposed across-the-board. We will discuss our views with officials in your agency and OMB so that the Solar Energy Industries Association position is clearly understood. We also reiterate our support for equitable funding of the DOE solar program vis-a-vis other DOE federal R&D programs.

Thank you for your serious consideration.

Sincerely,

Walter J. Hesse	Roger Little	Dick Joyce
Dr. Walter J. Hesse Chairman SEIA Solar Thermal Power Division	Mr. Roger G. Little Chairman SEIA Photovoltaics Division	Mr. Dick G. Joyce President SEIA Heating and Cooling Division

Mr. **Sklar**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Our next panel will be Dr. Harold M. Hubbard, Director of the Solar Energy Research Institute; Dr. Donald L. Klass of Biomass Energy Research Associates; and Mr. Thomas O. Gray, the Executive Director of the American Wind Energy Association.

Dr. Hubbard, I guess you're the leadoff person.

We want to welcome all of you here and thank you for joining us this morning.

Dr. Hubbard.

STATEMENT OF DR. HAROLD M. HUBBARD, DIRECTOR, SOLAR ENERGY RESEARCH INSTITUTE, GOLDEN, CO

Mr. **Hubbard**. Thank you for inviting me back this year. It's getting to be a yearly ritual; and when I met with you last year, I gave you a rather detailed history of SERI. I talked quite a bit about SERI's organizational structure and about its programs. I do not propose to repeat that today.

I would like to reiterate a couple of basic points I made at that time. One is, simply, that I think solar research and development is a long-term project. You raised that issue with your last question, and I believe it's a long-term project, just as many of the other research initiatives within the Government are.

Mr. **Fuqua**. I agree with you, but it appears that there are some people in this town who don't agree with us, and I was just trying to make that point and get some good advice other than myself, that it is long-range and energy is going to be around and be a major player for many years to come.

And I didn't mean to interrupt you.

Mr. **Hubbard**. Well, thank you for reinforcing that.

I also think that renewable energy is an important alternative and that it deserves support. And then the last point that I made last year was that the proposed 1986 budget was at a reasonable level suitable to the circumstances, and would permit us to maintain a productive program. And I think that's been so, although I also said there would be some rebalancing in the program as a result.

Now, some circumstances have changed since then. Certainly, the decline in oil prices, the increased emphasis and concern about the Federal deficit; these are affecting the circumstances under which we operate. There has been appreciable progress within the solar technologies. There has been appreciable maturation in SERI as an institution. And then I want to call the subcommittee's attention to two reports from the Energy Research Advisory Board that I think are pertinent to this program and this situation. I have spoken to all of that at some length in testimony which I have submitted for the record.

Mr. **Fuqua**. We'll make all of your prepared statements a part of the record, if you wish to summarize.

Mr. **Hubbard**. Fine.

Mr. **Fuqua**. Under the rules that were outlined earlier.

Mr. **Hubbard**. I'll try to be briefer with the testimony than the written statement, and I think I will be.

I am talking from a kind of parochial position. You understand that I'm a technocrat; I believe in science and technology. I believe in the program. I think SERI is a great place and I believe we've got a super staff. I think I could substantiate that, but those are my biases and my premises, and maybe I just ought to let you know where I'm coming from.

First thing I referred to was oil prices and the decline in oil prices. How you feel about that depends on where you stand. I come from Kansas, and if you come from Kansas it's a little bit—at least, that's my home State—if you come from Kansas, you feel a little bit like Mr. Barton did about the issue. There are some good things about it, of course; it has some positive things to do with the economy. It gives us some time to deal with the energy issue. I think that's important.

Other than that, however, I would say that current oil prices and their fluctuations are somewhat irrelevant to the long-term strategy for energy R&D. The Energy Research Board takes that position. You can't really predict what prices are going to be, and what we're concerned about is, what is energy going to cost a decade, two decades, three decades hence? And what is our situation going to be?

Federal deficit—certainly, budget restraint is a national priority. It's a fact of life, and we who are in R&D have to take that into consideration. It means that the programs that we propose are going to require stronger justification. We've got to pay attention to the Federal role. We've got to be sure there's a national need. We've got to look at the probability of success. And it's going to put a premium on good management, cost-effective management. It's going to put a premium on good planning. It's going to require that we make a good choice of objectives. In the process of doing that, we have to pay some attention to balance in the program—balance at all levels. That's not necessarily going to be too easy to do.

The two Energy Research Advisory Board reports that I referred to—one was the ERAB solar panel report which was done in response to a request from the Under Secretary. And in the process of that report, the panel recognized that there is a primary leadership role for SERI in solar research, that there is a strong leadership role for Sandia National Laboratory in engineering systems; that there was in process a consolidation of coordination, planning, and analysis at SERI, and they felt other laboratories should be used as they had specific expertise. They recognized that a certain research diversity is important. They recognized and encouraged the participation by industry and by universities in the whole process.

They recommended that the Department, assisted by SERI, establish a consolidated technical assessment and analytical capability, and we are proceeding to do that.

In the Energy Research Advisory Board report which laid out guidelines for DOE for long-term civilian research, that report defines objectives; it set out an evaluation criteria on those objectives, and the evaluation criteria are attached to my written testimony.

After some initial skepticism and a lot of hard-nosed discussion among the people on the panel, we concluded that—and I was on the Supply Subpanel—the general conclusion was that solar and renewable energy meets those criteria, and that it addressed all the objectives, and that its potential is large and, therefore, it deserves substantial Federal support.

They stressed the fact—as I've already mentioned—that oil prices are variable, unpredictable, and that alternative energy R&D strategies should not be tied to or influenced by current oil prices.

They encouraged DOE to establish a strategic planning process so that R&D goals and priorities could be established, and I think we've already heard from Secretary Fitzpatrick that that is ongoing and is being addressed.

R&D accomplishments and promise for the future—if you go back to the 1970's, solar was pretty much an exotic idea. If you look at it today, after 10 years of outstanding progress, I think you can see that there is a strong Federal and industry consortium and partnership that has emerged, and I think Federal research funding was critical to that. There are several mature technologies that are contributing now to our energy supply, particularly biomass and hydropower. There are several new technologies that show great promise and are well on the way—PV, wind, building active and passive space heating, solar thermal; you've heard a lot about that from earlier witnesses and I don't need to go into it. Research programs in biofuels are doing very, very well.

So I think you've got to say that progress is really moving along. At SERI, in applied research, we're making excellent progress in advanced photovoltaic materials; energy storing materials is coming along well. You've already heard a reference to aperture research and smart windows. We think thin film solar collectors are something that we're proud of, and that's moving. We've done some really interesting biotechnological work on the development of new organisms for the fermentation of wood, and that all looks good and I think you'll hear more about that from the other witnesses.

There is something I would like to emphasize, though, that I think is sometimes overlooked, and that's the role of basic research in the whole solar program. There are two particular accomplishments that we're proud of at SERI. One is some really scientific world-shaking advances in quantization in photoelectric chemical systems. Now, that sounds a little esoteric, but it's really basic to what happens in photochemical processes.

Another thing that we're really happy about is some work that we did in conjunction with the University of Nebraska. It was a basic study on the role of manganese in greenplant photosynthesis, and we developed techniques that can advance that further.

So I'd just like to say that just as NASA's space exploration program has contributed to this country's scientific and technical base in other areas, such as biomedical science and computer science, so will solar research contribute to our broader knowledge of atmospheric science, life science, and materials science.

Another thing that I think is overlooked is the scientific sophistication, the high scientific or high technological aspects of solar R&D, and maybe I can emphasize that by just giving you some anecdotal evidence.

On Tuesday, a distinguished professor from one of the major German universities came by to see me. He is a professor of biophysics. He is formerly the Associate Director General of the International Atomic Energy Agency in Vienna. He came to the Solar Research Institute simply because it is now being recognized as the world center for solar research. He said there is no other place like it; he had visited Japan, he had visited Israel, he had visited Canada because he's in the process of developing the background and the recommendations of the German government for the establishment of a solar research institute at his university. He says the United States is No. 1 in solar, but he says it's going to have to work hard to stay there. He came to us, having been in Japan immediately prior to that—very impressed with what they're doing in photovoltaics, and he feels that we're going to have to work hard to maintain our program.

He did say that SERI is unique in that its research in basic sciences relative to solar energy, has a world-wide reputation, and is the only place you can go where there are experts in every technology. Then he finished with something that really kind of amazed me. I started my technical career in nuclear chemistry and in nuclear energy, and this gentleman has spent almost his entire career there. And he said, "The nuclear field is so narrow relative to solar technology. It's narrow in the scientific sense; it's narrow in an application sense, and you really ought to get out the message that solar research is really high technology, it's really high science, and that your country has to work hard to stay in the lead." And we intend to do that.

You asked me to talk about the 1987 budget and its implications for SERI. SERI has matured over the last several years, and as it has matured, DOE has looked to SERI for leadership in program integration and planning and assessment and field management, and I think we're well-positioned and well-staffed to carry out those responsibilities in research management and in the performance of research and in the planning and coordination of it, and as a counsel to both DOE and industry. I think that's an important thing to stress; industry needs someplace to go where the spectrum of solar technologies is understood and where they can get advice on what works best when.

There was a rather dramatic reduction in the budget at SERI, both staff-wise and scope, between 1981 and 1982. Since that time we have been pretty stable. Over the last 5 years, it has cost approximately $62 million to operate SERI. Subcontracting has been some $20 million of that, then $43 million for internal research, for administration, and for the management of subcontract research. About $2 million has been invested each year in GPE and GPP projects.

As we have gone about that stabilization and consolidation, we have reduced our overhead costs pretty substantially and we have transitioned administrative and service functions into research functions. So we've transferred administrative dollars into research dollars as that has gone forward. Our institutional plan submitted last year for the next 5 years projected a relative stability at SERI and projected a somewhat increased role, slightly increased subcontracted research, and the in-house research remained at the present level or just a little bit above that.

With respect to 1987, we have as yet received no guidance. I think you can say that in principle, SERI at its present level, present role, could be accommodated within the proposed budget; but in practice, that's going to be very, very difficult. So at some level, we'll simply have to make some hard choices. And we're prepared to do that, if it's necessary. It might require a redefinition of SERI's role. We've been through things like that before. I think we've shown flexibility. I think we've shown constructive attitudes, and we will continue to do that.

In conclusion, let me simply say the following, that the size and complexity of our present energy supply system is long term—20 to 30 years—to make effective use of new energy systems. We need a robust system that utilizes domestic resources. We need a balanced program, and an effective program means continuity and stability.

The current oil situation, temporary as that may be, does give us time—time to bring to fruition an R&D program of great promise in which we have substantial investment. A well-planned solar R&D program carried out systematically over a longer period of time will produce better science, more useful technology, at less cost than a crash program.

The technical barriers limiting the performance of current solar technologies have been identified. To remove them does not require huge sums—by Government standards, at least—but it does require a stable and sustained effort.

I think the accomplishments of the program to date and its promise for the future and the Nation's need for a secure energy future argue for continued funding at a substantial level. Current budgetary considerations may mean that it will be necessary to reduce current funding, and that does lie outside my area of responsibility. If that is the case, then we in the program will have to make some hard choices; at some level, it will be necessary to withdraw from certain technology areas, and it will be particularly important that there be excellent research planning and excellent management judgment going into those decisions. I am confident that the Department can work with SERI and with Sandia and with the field structure to see that that happens, and that we can accommodate to changing conditions as they come up.

I will return to my basic point, that we have a long-term program that needs continuity and stability insofar as circumstances will permit that.

Thank you.

[The prepared statement of Mr. Hubbard follows:]

TESTIMONY OF DR. H. M. HUBBARD
DIRECTOR
SOLAR ENERGY RESEARCH INSTITUTE

BEFORE THE
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE

Washington, D. C.

February 27, 1986

I. INTRODUCTION

Mr. Chairman and members of the Subcommittee, thank you for the invitation to meet with you again. When I came before you last year at the hearings on the fiscal year 1986 budget authorization request for DOE's programs in Conservation and Renewable Energy, I discussed in some detail the history of the Solar Energy Research Institute, (SERI) its mission, organizational structure, and the relation of SERI's activities to the activities and roles of universities, private industry, and other Federal laboratories in solar research. In general, my comments on those subjects then are valid still, so I will not impose them on you again today; they are already in the record. But, I would like to reiterate some of the things I said in my concluding statement last year.

First is my conviction that, "A vigorous program in renewable energy research and technology development is a vital component to our Nation's future energy security." Second, that solar R&D is a long-term project with a high probability for "meeting its goals over the next ten to twenty years, providing there is stability in the National program." And third, that "the proposed Fiscal Year 1986 budget would maintain the solar R&D effort at a reasonable and productive level, and maintain SERI's ability to fulfill its mission, although there would be shifts and rebalancing among the various programs." These statements, made in March of last year, still represent my view today. But since that time, several things have happened that have affected and will continue to affect the atmosphere and circumstances in which the DOE Solar Program and SERI operate.

These events have implications with respect to the proposed 1987 budget. They include the dramatic recent decrease in oil prices, and increased public concern about the federal deficit. More specific to the Program and to SERI have been the technical progress made in solar R&D, continued maturation of SERI as an institution, and the issuing by the Energy Research Advisory Board of two pertinent reports: "Guidance for DOE Long-Term Civilian Research and Development," and "Report of the Solar Panel of the Energy Research Advisory Board." Today I would like to discuss with you the implications of these changes, the reasons behind my conclusions that solar research and development deserves and needs continued federal support, some recent research accomplishments, and the promise of progress in the future. Finally, I would like to make some comments on the budget outlook and its impact on SERI in FY 1987.

SERI is the only laboratory whose primary purpose is to carry out research and development for DOE's Office of Conservation and Renewable Energy. SERI is fully committed to generating the science and technology necessary to achieve the objectives of this Office and realizes the necessity of modifying its activities and efforts in response to DOE policy guidance, program goals, and resource availability.

In addressing today's topics, I will be speaking from the perspective of an R&D laboratory director who believes in the importance and validity of the program he is supporting, and in the mission and capability of his laboratory. Admittedly this perspective is somewhat parochial and certainly does not take into account the full gamut of factors that must be considered by the people in the government who are charged with making final recommendations and decisions on the budget.

II. IMPLICATIONS OF CHANGES

OIL PRICES

Adjusted for inflation, the market value of crude oil is now at the level which existed in the 1973-1979 period (after the first oil price shock and before the impact of the Iran-Iraq conflict). Does this mean that OPEC is dead and our troubles are over? In my opinion, the U.S. vulnerability to supply interruptions or rapid increases in the price of oil is just as great as ever. The present situation is the result of the continued success of non-OPEC oil exploration efforts in Mexico and the North Sea, for example, and demand reduction due to the implementation of cost-effective conservation measures. Production from non-OPEC sources is expected to decline sharply in the early 1990's while at the same time consumption, driven by low prices and economic growth, is expected to rise substantially. The implications are that we will be forced to turn to OPEC for rapidly increasing amounts of oil, putting them in effective control of prices once again. This time, however, the conservation option will not be so accessible because the easy things have already been done. We will not easily be able to reduce our demand for petroleum. The impacts on our economy and our national security could be severe. This scenario, coupled with what we know to be the long lead times (20-30 years) required to integrate new energy technologies into our economy, makes it imperative that we continue energy supply R&D programs undisturbed by the vicissitudes of energy markets.

PRESSURES TO REDUCE FEDERAL DEFICITS

The public concern about federal deficits is well-founded. We do need to get our finances "in order" as a nation, and enactment of the Gramm-Rudman-Hollings Act reflects these concerns. Budgetary restraint will be a fact of life for the next several years and this implies several things to energy R&D managers such as myself. Cost-effective management and implementation of programs will be imperative. This means clarifying and simplifying management and operating roles within the programs and implementing consolidation wherever it is cost-effective. Program objectives will be subject to increased critical scrutiny. We must be prepared to present a compelling justification for proposed activities. Finally, as budgets are reduced, those who oversee these activities must be concerned that proper balance and critical mass is maintained at all levels across the national program.

ENERGY RESEARCH ADVISORY BOARD

The two ERAB reports published this winter have significant implications for the present situation. The first report, "Report of the Solar Panel of the Energy Research Advisory Board" is in response to an inquiry by Under Secretary Salgado as to the present implications of a 1982 ERAB recommendation regarding consolidation of the Solar R&D Program. In its report, the panel offered seven observations and seven recommendations. It seems pertinent to highlight two of each at this point:

OBSERVATIONS

- "Primary responsibility to serve headquarters by coordinating the planning and analysis activities for all solar programs is being consolidated at SERI to improve the consistency and effectiveness of the overall planning function.

- As a result of the consolidation, leadership roles for SERI and to a lesser extent, Sandia Laboratories, have emerged. Both laboratories have well defined research management functions. SERI is also specializing in research, while Sandia is more involved in engineering research. The programs have become better coordinated and overlapping management functions have been substantially eliminated. In general, the other laboratories are being drawn upon for the talent of individual researchers."

RECOMMENDATIONS

- "Reasonable diversity in laboratory participation in research, along with continuation or even increases in the base of university and industry research activities, must be maintained to provide adequate opportunity for collaboration, competition, creativity and technology transfer and yet assure an efficient and effective use of limited resources.

- Program choices will continue to be needed; we must foster the winners, phase out R&D as good technologies are implemented, and terminate or redirect less promising

> alternatives. The Department should establish a consolidated technical assessment and analysis capability within the Department, assisted by SERI, to assess the relative potential of the various solar technologies and cross-cutting research requirements, to evaluate research activities and results, and to provide for industry and university contributions to a coordinated research planning process."

As these recommendations are implemented by DOE, I believe we will see a stronger, more attractive solar R&D program emerge.

III. THE ARGUMENT FOR CONTINUED SUPPORT OF SOLAR R&D

In the second study, "Guidelines for DOE Long-Term Civilian Research and Development," the Energy Research Advisory Board took pains to explicitly define both the objectives of and the evaluation criteria for DOE civilian R&D. These definitions and the six major recommendations of the report are attached to my statement and I will not restate them here. They recognize the national need for a robust array of economically attractive supply options, not vulnerable to foreign intervention, and acceptable from the standpoint of environmental and public safety concerns. They also note the values inherent in the advancement of fundamental scientific knowledge.

In carrying out its study, ERAB utilized a baseline scenario of the future developed by DOE in support of National Energy Policy Plan IV. At the conclusion of its work, the Board considered several alternative scenarios to test its conclusions. Among these was the scenario: "Longer than expected softness in oil/gas prices." Interestingly, the ERAB felt that this (and other alternate scenarios) had minimal impact on their conclusions.

The Board concluded that continued attention to all supply options is required "...if the national objective of a robust, secure, safe, diversified, clean and economic supply of energy is to be guaranteed for the future." With regard to renewable energy, the Board stated:

> "Renewable energy sources are numerous, with some having potentially large energy contributions. The key task is to focus on technologies able to make a significant contribution to a balanced mix of supplies and to maintain consistent support."

Furthermore, the Board concluded that "selected high risk areas" of renewable energy R&D "require substantial DOE support." Finally, ERAB encouraged DOE to establish a strategic planning process as the primary means for determining its R&D goals and for establishing R&D priorities.

Mr. Chairman, I served on that ERAB panel, and I can tell you that when we started, most of the other members were skeptical about the prospects for solar and renewable energy. These men, each an expert in his own field of energy supply, were inclined to dismiss solar and renewables as insignificant and the product of ideologic hopes rather than sound science and engineering. At the end of our study, solar and renewable energy received very favorable consideration. Why was this? In my opinion, Mr. Chairman, it is because the solar and renewable technologies meet the test of every objective and evaluation criterion established by ERAB.

The solar and renewable technologies already represent a significant portion of our national energy supply mix. Two mature technologies, direct combustion of wood and hydroelectric power, presently supply 6.7Q (9%) of U. S. energy needs. Recent DOE projections are that by the year 2010, 14.9Q (14%) of U. S. energy supply will come from these and the emerging renewable technologies (wind, PV, etc.). Even more exciting than this rapid (for energy markets) growth is the competitive potential which the technologies represent. DOE studies suggest that by the year 2010, adequate resources will exist and sufficient technology development will have occurred (at present funding rates) for these technologies to compete on an equal basis with conventional energy supply systems for 90Q of supply market! Coupled with this capacity to produce are the modularity, diversity, exportability and low environmental impact of projected systems. Overall the package seems to represent an attractive national investment. As I will discuss below, our continued progress in these technologies gives us every reason to believe that, given adequate support, they can ultimately provide a substantial fraction of our nation's energy needs at an attractive price.

IV. ACCOMPLISHMENTS AND PROMISE FOR THE FUTURE

I would like to take the next few minutes to focus on major solar energy developments during the past decade. As you will see, there has been significant progress made both technologically, and economically.

In the early seventies solar energy was basically an exotic energy idea but in the last decade we have made outstanding progress in determining the technology and economic feasibility of the solar technologies. As a result, solar energy is receiving increasing recognition as a valuable component of a robust energy supply system. The emerging solar energy technologies such as photovoltaics, wind, solar thermal, passive and active systems and biofuels have received substantial R&D attention from the private sector as well as from the federal government.

A strong partnership has developed between industry and government. This has been enhanced by direct federal funding for solar energy technology research and development, and to a lesser degree, by federal and state incentives to assist investors, manufacturers and operators.

Currently several emerging technologies are already making important contributions to the Nation's energy supply. In addition to photovoltaics and wind, on which I will focus later, other technologies, such as solar thermal, show great promise for significant additional contributions within the future energy marketplace. Solar thermal parabolic dishes have achieved record efficiencies of approximately 30% solar-to-electricity conversion. These and other commercial solar thermal systems are already producing electricity at about 15 cents per kilowatt hour.

PHOTOVOLTAICS

Federally funded research and development has played a key role in the advancement of the photovoltaic technologies over the last ten years. This has been apparent in three key areas:

o Efficiency - photovoltaic modules have been produced with greater than 15 percent conversion of sunlight to electricity.

- Durability - photovoltaic modules have been engineered to operate reliably for more than 20 years.
- Manufacturability - the feasibility of low cost production has been established.

As a demonstrated measure of progress, the industry's manufacturing cost, reflected in product price, has dropped more than an order of magnitude since terrestrial photovoltaic research initiatives began ten years ago. However, costs must be reduced much further to attain the program goal of supplying large quantities of power to utility systems. This reduction will only come through further aggressive research, both basic and applied.

The strong partnership which exists in the PV research program between industry, universities, and the federal program has built a momentum which promises to successfully meet or exceed most of the goals of the Department of Energy's Five-Year PV Research Plan. This partnership has resulted in significant advances in performance and reduction in cost occurring during the last fiscal year.

Although fragile, and at present not profitable for most participants, the U.S. PV industry is intimately involved with the DOE Program on a cost and risk-shared basis as exemplified in the recently announced amorphous silicon three-year, $50 million initiative. These programs require a 50% cost share by industry to qualify for this competitive procurement. In addition, we have expanded the involvement of universities in the program through an unencumbered three-year commitment to the winners of annual competitions. Such long-term contracts allow continuity and the commitments to be made to graduate student programs, forming the basis for trained manpower for the industry. In addition, this program provides a sound scientific base and a source for new and innovative ideas for the program.

Photovoltaics is a "high tech" industry with excellent potential for generating substantial exports and contributing to our balance of payments position. The Japanese, as you know, are aggressively pursuing photovoltaics as a new technology to help them continue to corner selected world markets. An aggressive domestic research program in partnership with industry assures that U. S. technology will be globally competitive.

WIND ENERGY

At this point, let me say a word or two about wind energy. Wind machines, as you know are among the oldest power-producing mechanical devices on earth but their recent rebirth and growth is rather remarkable.

During the past decade, a substantial and expanding wind technology base has helped drive down the average cost of installed wind-powered generators. In 1975, only a few United States firms were selling wind turbines. A decade later, more than 8000 wind units have been sold. These machines represent a total generating capacity of more than 600 megawatts. Wind technology has been advanced due to better understanding of the features of wind that affect machine performance and reliability and the corresponding response of the machines.

Progress in the development of wind energy technology has been substantial. The average 30-year levelized equivalent cost of electricity from wind was more than $1.50 per kilowatt hour in the late 1970's. The cost from today's state-of-the-art wind machines is estimated to be 10 cents to 15 cents per kilowatt hour.

Further research is needed in order to achieve an improved understanding of the basic physical phenomena involved in converting the wind to useful energy. A more complete understanding of these phenomena will help researchers overcome fundamental problems that have hampered progress in the past. Improvements in cost, performance, and lifetime of both vertical and horizontal-axis machines are expected to reduce the cost of wind-generated electricity to about 4 cents per kilowatt hour.

With respect to international markets and global competition, wind is in the same position as photovoltaics in that it has excellent potential for generating substantial exports. However, the Europeans are aggressively competing with us in further developing the wind technologies. We have to pursue an aggressive domestic R&D program in partnership with industry in order to remain competitive.

SERI R&D CONTRIBUTIONS

I would like to digress at this point and cite some specific examples of SERI's R&D contributions, not only in the areas of wind energy and photovoltaics, but in other solar energy research areas as well.

In the 1977 to 1985 period, the two primary achievements of the SERI and Rocky Flats wind energy programs have been sponsorship of the development and testing of a first generation of prototype wind systems and the adaptation of existing aerospace analytical codes for use by wind systems designers in solving simplified design problems.

Several of the prototype wind turbines matured into commercially viable machines. These included wind turbines marketed by the North Wind Power Company, Enertech Corporation, Omnion and others. The program explored a wide variety of advanced design concepts in the 5-meter to 25-meter diameter size range, as well as a number of highly innovative systems, promoting progress by American industry and providing an invaluable, documented technology base. The wind turbine industry has also incorporated several design concepts (soft or passive rotor controls, the use of induction generators) and manufacturing techniques (fiberglass blade development) pioneered or refined during the development programs.

Our experience with prototype development indicated that the use of aerospace and civil engineering design tools proved to be inadequate in predicting wind turbine performance, structural loads, and fatigue life. Accordingly, we sponsored research to adapt the most promising existing models for use by the wind turbine industry. Further model development is required to enable designers to incorporate configuration refinements, scaling effects and the impacts of unsteady wind conditions that produce cumulative damage during the long lifetimes for which wind turbines must be designed.

In the area of photovoltaic research, SERI maintains a center of excellence research program which is complementary to the National program and supports the Department of Energy's Five Year PV Research Plan goals. During 1985, the Institute received an I-R 100 Award for a major development in photovoltaic research. This is the fourth

I-R 100 Award for SERI in the past four years. Our scientists developed a Volume-Indexed Secondary Ion Mass Spectrometry system which enhances our surface analysis capabilities. These enhanced capabilities will be used to examine the compositional and chemical properties of internal surfaces and interfaces in solar cell materials and devices.

Our researchers have also developed a greatly improved and more economical process for purifying silicon for use in the fabrication of photovoltaic cells. The new process should reduce the cost of solar-grade silicon dramatically and make solar cells more competitive in the marketplace

Our scientists work closely with the photovoltaics industry to assure smooth and timely transfer of the technology. SERI also maintains high quality user-support groups in the Solar Insolation Resource Assessment areas for testing and characterizing materials, devices and advanced systems in the measurements and support areas.

Materials research in the Institute's Solar Heat Division has resulted in the following accomplishments:

- Electrochromic Window Materials — These coating materials can change the opacity of a window in response to an applied voltage. Researchers at SERI have fabricated and tested electrochromic devices with areas up to approximately a square foot. Manufacturing costs for these electrochromic window coatings are estimated at $1 per square foot.

- Solid-state, Phase-change Thermal Storage Materials — These materials increase the efficiency of passive solar technologies by increasing the heat storage capacity of building materials. SERI scientists have developed materials that can more than double the heat storage capacity of concrete, wood and gypsum, leading to more energy efficient buildings.

- Flexible Silver/Acrylic Film — In partnership with the 3M Company, SERI has developed a flexible silver/acrylic film with reflectance properties matching those of some silvered glass reflectors now in commercial use, with tremendous savings in weight and the promise of a resulting reduction in costs.

- Stretched Membrane Heliostats — These devices offer the potential for reducing the cost of this portion of the solar thermal systems to levels low enough that the overall systems will be cost-competitive. SERI researchers have fabricated and tested modules as large as three meters in diameter.

Biofuels researchers in our Solar Fuels Division, have invented a pressurized, oxygen-blown, fixed-bed, down-draft gasifier that converts biomass such as agricultural wastes, wood, or municipal wastes into medium-Btu gas for fuel use, or synthesis gas for conversion to methanol. A private firm in the United States has scaled up this system to process 20 tons of wood per day to produce fuel gases for engines and other applications.

Our researchers are working with certain aquatic microalgae species that can be stimulated to convert large fractions of their cell mass to oil. Our scientists have identified and isolated several such species and have developed a systematic method of evaluating microalgal lipid productivity.

In genetic engineering research, we are making progress toward developing an organism that will provide the ability to produce ethanol from the xylose portion of wood.

SERI BASIC SCIENCE CONTRIBUTION

SERI conducts a variety of activities in basic energy sciences for the Department of Energy's Office of Energy Research. Exploratory programs in materials, photoconversion, chemical, and biological energy sciences provide a fundamental base for applied research in specific program areas and are essential in establishing the scientific understanding necessary for continuing progress in specific renewable technologies. Our basic research has resulted in scientific developments that can be applied simultaneously to several areas within the solar technologies and may open exciting new avenues for energy technology development. Following are two examples of SERI accomplishments in the area of basic research:

- Quantization in Photoelectrochemical Cells — Photoelectrochemical cells use sunlight to drive electrochemical reactions which can produce fuels. SERI researchers, using a semiconducter superlattice electrode, were the first to observe the effects of discrete energy levels in a photoelectrochemical cell.

- Surface-Enhanced Raman Scattering Spectroscopy — SERI researchers used a new technique, developed in cooperation with the University of Nebraska, to pinpoint the location of manganese in the membrane structure. Manganese is the element required for water splitting in green plant photosynthesis. This development will lead to a much better understanding of how membranes function.

These are just some of the research accomplishments that have occurred at SERI and throughout the Solar Program. As a result, not only has there been real progress in improving the technical and economic feasibility of the solar technologies over the past decade, but we can look forward with confidence to continued progress.

In addition to contributing toward our energy security, the fundamental research done at SERI, and by the other laboratories, in the course of doing solar research will undoubtedly prove useful elsewhere. Just as NASA's space exploration program contributed to our country's scientific and technological base in other areas such as biomedical science and computer science, so will SERI's solar research contribute to our broader knowledge of atmospheric science, life science, and materials science.

V. BUDGET OUTLOOK AND ITS IMPLICATIONS ON SERI

As is well known to the members of this Subcommittee, the DOE Solar Program budget decreased from $480 million in FY 1981 to $157 million in FY 1986. The most dramatic reduction in the Program budget and a corresponding reduction in SERI's budget and staff occurred from 1981 to 1982. Since then, SERI's rate of expenditure has been relatively stable. The Program budget has continued to decrease but SERI has been able to adjust to shifts in funding and accommodate changing circumstances. In the process we have reduced our overhead costs significantly, transforming management administration dollars into research dollars.

Over the past five years, SERI expenditures have averaged $62 million per year, with subcontract research activities of about $20 million. SERI's operating costs averaged $43 million per year during the same period. These include the costs of on-site research, management of subcontracted research, facilities, administration, and planning. Capital expenditures for scientific equipment and general plant projects have been roughly $2 million per year.

As program resources have declined and as SERI has matured, the DOE Office of Conservation and Renewable Energy has looked increasingly to SERI for leadership in the areas of program integration, long-term planning, and program field management. Thus, SERI has become in fact as well as in name, "the primary federal laboratory for solar R&D." In response to DOE's needs, we have developed a strong management team and an excellent research staff competent in the broad spectrum of solar related scientific and engineering disciplines as well as solar technologies. In so doing, we have become a source of counsel for scientific knowledge and technical information not only for the Department, but also for private industry. To continue in this broad role as the Nation's lead center for solar research, we must maintain a stable organization, sufficiently broad in scope and deep in capability to meet the needs of DOE and industry.

In our Institutional Plan for FY 1984/85-FY 1990, submitted in March of last year, we projected a small increase in technical staff during the six-year period and no growth in administrative and support activities. Areas of emphasis included achieving consistent excellence in research quality and improved cost effectiveness, and continuing to develop close contacts with the solar industry, the universities, and other government laboratories engaged in the performance of solar research. This Plan assumed that the DOE renewable energy budget would be relatively stable and that the trend of increased reliance on SERI would continue.

In general, I feel that SERI is well-staffed and positioned to carry out its present role. In its early phases SERI went through a dramatic and disruptive growth period, followed by a precipitous and equally disruptive contraction. I hope both of these conditions can be avoided in the future; but that does not mean we cannot adjust to change. We are an active and dynamic organization that has already shown its ability to adjust to changes in program emphasis and funding.

With respect to FY 1987, we do not as yet have any budget guidance from the Department. In principle it should be possible to accommodate SERI's current costs and staff plans within the proposed budget. But in practice I think it is clear that it would be difficult to do so. If circumstances are such that our mission and assigned responsibility must be redefined to accommodate a reduced research budget, we will look for opportunities to do that constructively and effectively while maintaining continuity and stability to the degree possible.

VI. CONCLUSIONS

Our energy supply and distribution system is huge and complex and is characterized by lead times of between 20 and 30 years to make effective use of new energy sources. We have only a limited time to position ourselves to avoid the next energy crisis and we must use this time to strengthen our energy options. Secretary of Energy, John Herrington, in a recent address said, "One of the bright sides of today's relative energy stability is that it gives us the opportunity to build a more solid base of technical knowledge for resources that we will have to count on in the future, resources such as coal-nuclear power—and the third leg of what I call the 'energy triad' for the 21st century-conservation and renewable energy."

As the Secretary said, the current stability in our energy supply, temporary as that may prove to be, gives us time. We should take advantage of that time to bring to fruition an R&D program of great promise in which we have already made a substantial investment. A well-planned Solar R&D Program carried out systematically over a longer period of time will produce better science and more useful technology at less cost than a crash program carried out in an atmosphere of emergency and crises.

The technical barriers limiting the performance of current solar technologies have been identified and are much better understood, thanks to the progress made over the past several years. To remove them does not require huge expenditures of money, but it does require a sustained long-term effort. Given that effort, I think the current technical and performance objectives of the Solar R&D Program will prove to be modest and that we will exceed our expectations.

The accomplishments of the Program to date, its promise for the future, and the Nation's need for a "robust array of energy supply options" argue for a continued investment in solar R&D. It appears that larger budgetary considerations may not permit maintaining the current level of Program investment. Such a decision lies outside my area of responsibility. However, if that is the case, then we in the Program will have some hard choices to make in order to invest available funds as wisely as possible and at some level it may be necessary to withdraw from certain technology areas.

As I already stated, how SERI would be affected by the proposed 1987 budget is not clear for we have not yet received '87 guidance from the Department. I would make two points. First, for SERI to continue to serve DOE and the industry as the Nation's lead center for solar research, we must remain a substantial and broadly capable research organization, but that is not to say that we cannot change to meet changing circumstances. Second, SERI has shown its ability to adjust to changing priorities and budget fluctuations, so if our assigned responsibilities are redefined as a result of a reduced budget, we will accommodate to that as constructively and effectively as possible.

ATTACHMENT I

GUIDELINES FOR DOE LONG TERM CIVILIAN RESEARCH AND DEVELOPMENT

APPENDIX D, VOLUME I

OBJECTIVES AND CRITERIA FOR JUDGING DOE CIVILIAN RESEARCH AND DEVELOPMENT

DOE MUST HAVE CLEAR OBJECTIVES AND CRITERIA FOR JUDGING ITS CIVILIAN RESEARCH AND DEVELOPMENT PROGRAMS. WE FOUND NO SUCH STATEMENTS READILY AVAILABLE, AND THEREFORE WE DEVELOPED A SET, AS A BASIS FOR OUR DELIBERATIONS:

I. OBJECTIVES FOR DOE CIVILIAN RESEARCH AND DEVELOPMENT

- TO PROVIDE A ROBUST ARRAY OF ECONOMICALLY ATTRACTIVE SUPPLY AND EFFICIENT END-USE OPTIONS TO HELP SATISFY THE NATION'S UNPREDICTABLE ENERGY FUTURE.
- TO CONDUCT RESEARCH TO IDENTIFY AND MITIGATE THE IMPACT OF ENERGY PRODUCTION AND USE ON HEALTH, SAFETY, AND THE ENVIRONMENT.
- TO ADVANCE FUNDAMENTAL SCIENTIFIC KNOWLEDGE AND EDUCATION IN THE DISCIPLINES THAT IT SUPPORTS.

II. CRITERIA FOR JUDGING DOE CIVILIAN RESEARCH AND DEVELOPMENT

A. ECONOMIC

- MUST HELP PROVIDE ADEQUATE SUPPLIES OF LIQUID, GASEOUS, SOLID FUELS OR ELECTRICITY AT REASONABLE COSTS.
- MUST HELP PROVIDE FURTHER COST-EFFECTIVE IMPROVEMENTS IN THE EFFICIENCY OF ENERGY USE.

ATTACHMENT I
PAGE 2

- MUST PROVIDE THE GOVERNMENT WITH COST-EFFECTIVE TECHNOLOGY TO MEET ITS OWN SPECIAL NEEDS.

B. SECURITY

- MUST HELP ENSURE THAT TECHNOLOGIES ARE AVAILABLE ON A TIMELY BASIS TO PROVIDE ADEQUATE NATIONAL PROTECTION AGAINST SUPPLY AND COST VULNERABILITIES, COMPATIBLE WITH FOREIGN POLICY AND FOREIGN TRADE CONSIDERATIONS.

C. ENVIRONMENTAL

- SHOULD HELP ENSURE THAT ENVIRONMENTAL HEALTH AND SAFETY ISSUES ARE ADDRESSED EARLY-ON TO MINIMIZE UNNECESSARY ADVERSE IMPACTS ON THE ENERGY MARKETPLACE.

- SHOULD PROVIDE ACCURATE, FACTUAL ENVIRONMENTAL INFORMATION THAT WILL PROMOTE INFORMED, RATIONAL PUBLIC CONSIDERATION OF NEW ENERGY TECHNOLOGIES.

D. ADVANCE SCIENTIFIC KNOWLEDGE

- PROVIDE FUNDAMENTAL SCIENTIFIC UNDERSTANDING IN THE GENERAL FIELD OF ENERGY.

- PROVIDE IMPROVED UNDERSTANDING AND/OR TECHNOLOGY (MATERIALS, CHEMISTRY, PHYSICAL PRINCIPLES) THAT CAN ENHANCE CURRENT AND FUTURE ENERGY SYSTEMS OR PROCESSES.

- HELP DISCHARGE DOE'S ASSIGNED RESPONSIBILITIES TO CONDUCT FUNDAMENTAL RESEARCH IN SPECIALLY DESIGNATED FIELDS.

- PROVIDE APPROPRIATE TRAINING AND PROFESSIONAL DEVELOPMENT OPPORTUNITIES NEEDED TO HELP ASSURE AN ADEQUATE SUPPLY OF TRAINED MANPOWER TO THE ENERGY ESTABLISHMENT.

ATTACHMENT II

KEY RECOMMENDATIONS FROM "GUIDELINES FOR DOE LONG-TERM CIVILIAN RESEARCH AND DEVELOPMENT"

- REDUCE U.S. LONG-TERM DEPENDENCE ON FOREIGN OIL.
- ASSURE AN ADEQUATE SUPPLY OF ECONOMICAL, SAFE AND ENVIRONMENTALLY ACCEPTABLE ELECTRIC POWER.
- CONTINUE THE DEVELOPMENT OF A STRONG NATIONAL BASIC SCIENCE BASE.
- ENSURE THAT INCREASED FUNDING OF THE SUPERCONDUCTING SUPER COLLIDER NOT PREEMPT OTHER DOE CIVILIAN R&D PRIORITIES.
- DRAMATICALLY UPGRADE DOE'S R&D MANAGEMENT CAPABILITIES.
- MAINTAIN A PROPER BALANCE AMONG THE DOE CIVILIAN R&D PROGRAMS.

Mr. Fuqua. Thank you, Dr. Hubbard.
Dr. Klass.

STATEMENT OF DR. DONALD L. KLASS, PRESIDENT, BIOMASS ENERGY RESEARCH ASSOCIATION

Mr. Klass. Thank you, Mr. Chairman and members of the subcommittee.

My name is Donald L. Klass and I am president of the Biomass Energy Research Association. BERA is a nonprofit association that was founded in 1982 by biofuels researchers to promote education and research related to the development of biomass energy systems, and to serve as a source of information on biomass policies and programs for our members and industry.

Each year, as we prepare to comment on the Federal role in supporting biofuels research, we survey our members' views on the needs for research and development. These comments are directly reflected in the recommendations we are presenting today.

First, let me take a moment to commend the subcommittee for the recognition it has given biofuels in recent years, Certainly, you have recognized the unique qualities and contributions of biofuels technology. For example, these technologies provide domestic, renewable substitutes for fossil-derived liquid, gaseous, and solid fuels, as well as electricity, by application of suitable conversion processes.

They contribute about 3 to 4 percent to the Nation's primary energy demand, and on a BOE—barrels of oil equivalent per day—basis, wood fuels contribute 1.2 million; octane-enhancing alcohol fuels in alcohol-gasoline blends, 32,000; electric power from municipal solid waste combustion plants, 8,200; and methane from municipal solid waste landfills, 2,400. This represents about $7 billion per year that is not expended on imported energy at a crude oil price of $15 per barrel.

Biofuels also provide excellent regional benefits; for example, 80 cents of every dollar spent on biofuels in a given region stays in that region, while 80 cents of every dollar spent on petroleum leaves the region. Biofuels create local jobs and income such as, for example, the 65,300 jobs and $1.3 billion in income in the Northeast that results from wood energy utilization.

Clearly, with relatively modest amounts of Federal research support, especially in comparison to other technologies, biofuels are making a significant contribution to the Nation's energy supply.

But technological barriers remain before advanced biofuels systems can be utilized. These must be addressed with continuing Federal support of basic and high risk research and development because biofuels technologies are the only ones capable of providing energy in all of its forms to all of our citizens without concern for resource depletion, import problems, and environmental safety.

These highlights demonstrate the substantial benefits to be achieved through continued biofuels research and development. However, new capabilities such as the fermentation of lignocellulosic materials to produce low-cost ethanol fuels, the production of medium-Btu gas at low cost, and the pyrolysis of biomass to produce oil products, offer the potential for enormously increasing the versatility and ultimate scale of biofuels technology in the United States. At the same time, these innovations present complex technical challenges that require the resolution of many problems. It is particularly appropriate that the Federal biofuels R&D program continue to maintain funding of biofuels for long-term, potentially high payoff technologies.

Before I describe BERA's recommended fiscal year 1987 funding priorities, let me take a moment to express some concerns that our membership has regarding the Department of Energy's biofuels program.

First, our recommendations emphasize the need for continuity of funding research in thermochemical and biochemical conversion. Answering fundamental questions about how various biomass fuels can be processed and efficiently converted is the keystone to a sound program to develop advanced biofuels systems; yet, this part of the program, we believe, has been disproportionately reduced over the last few budget seasons relative to other program elements. We trust the subcommittee will take this factor into consideration during its deliberations.

Now, I would like to highlight for the subcommittee some of the key aspects of our recommendations.

The thermochemical conversion program has made substantial strides toward its objectives and is just now entering the phase when innovations at the bench scale are being consolidated into meaningful technologies. Reductions in the program at this time would prevent the consolidation of many of these gains. BERA's members engaged in thermochemical conversion research are alarmed at the large reduction in funding for research activities that the program has already experienced.

Research should be continued to develop innovative advanced gasification processes for the economic and reliable production of gaseous fuels from both biomass and municipal solid wastes. Progress has been made on optimization of reactor designs and operating conditions to maximize the desired products. More research is needed to evaluate feedstock conversion characteristics and requirements. Continuing research should also address problems associated with the feeding of solids at high pressures and recycling to improve carbon conversion and to reduce environmental problems.

Although BERA supports funding for prototype testing on a cost-shared basis with industry, such testing should not detract from maintaining a vigorous thermochemical conversion program component.

Progress has also been made in achieving high yields of substitute fuel oils through the optimization of entrained pyrolysis conditions for maximizing liquid yields. Research and development efforts should continue to improve oil yield and to quantify oil product combustion and storage characteristics.

Overall, BERA recommends $8.9 million be directed to continue thermochemical conversion research in fiscal year 1987.

Bioconversion research has concentrated on the development of technology for the economical use of our vast lignocellulosic resources as feedstocks for fermentation and other bioconversion processes. The resistance of lignocellulose to biological attack and its multicomponent makeup continue to present many difficult R&D challenges. The Federal biofuels program should continue to address the problems of feedstock pretreatment, sugar recovery and fermentation, byproduct recovery and applications development, and wastewater controls. An assessment of biofuels technologies conducted in 1985 rated lignocellulose bioconversion technology as the foremost development need. Again, progress to date is just reaching the point where individual advances in the laboratory are being consolidated into meaningful processes.

BERA recommends that $6.8 million be directed to continue bioconversion research.

Biomass production technology development provides a much-needed orientation of cultivation strategies to produce high-yield, low-cost biomass feedstocks. Short-rotation intensive culture tree growth offers a unique way to produce large amounts of woody biomass over shorter periods of time for energy applications. Herbaceous biomass development offers high-yielding energy crops with major soil conservation benefits and new opportunities for the farmer. Aquatic biomass production has proven very constructive as a treatment method for municipal sewage and simultaneous feedstock production. It also has the potential of providing new ways to produce liquid fuels.

BERA recommends that $5.2 million be directed to continue biomass production research.

Since the regional programs were instituted 3 years ago, they have proven extremely valuable in facilitating the transfer of technology to the private sectors in their respective regions. Feedback through the regional programs has also proven beneficial in the fine tuning of the mission-oriented research programs, and has better communicated the utility of the biofuels program to those at the grassroots level. BERA believes the biofuels program can benefit substantially by enhanced communication with universities, industry, and the community of prospective biofuels end users. The December 1985 report released by the Energy Research Advisory Board also supports keeping a broad base of participation, especially with universities and industry, in the solar and renewable programs.

BERA recommends that $2.5 million be directed to continue the regional programs.

One final consideration in presenting a biofuels budget is the recognition of the challenge to the biofuels program management as a consequence of the consolidation of several previously autonomous programs into a single biofuels program. Although the consolidated biofuels program has strived to sustain the original objectives of the separate programs, it is obliged to do so within the constraints of a steadily reduced budget. Thus, the critical mass of individual research initiatives is challenged by both a declining budget and an increase in the total number of research activities. To help overcome these difficulties and sustain an innovative program, BERA recommends a total R&D budget of $23.4 million for fiscal 1987.

The Department of Energy Office of Conservation and Renewable Energy published an evaluation in 1985 to estimate the potential payoff of renewable energy options, including biofuels, prioritize R&D objectives over the next 5 years, and identify the Federal Government's role in accomplishing these objectives. This type of comprehensive analysis is extremely important, so much so that BERA recommends that this process be an ongoing one and that the results be applied to the makeup of the biofuels program to maximize the Nation's return on this investment. The formulation of a detailed 5-year plan which is updated on an annual basis and its critical review are strongly recommended.

I appreciate the opportunity of appearing before you today, and I would be very happy to answer any questions you may have, either now, or later on in writing. Thank you.

[The prepared statement of Mr. Klass follows:]

STATEMENT OF
DR. DONALD L. KLASS
PRESIDENT
BIOMASS ENERGY RESEARCH ASSOCIATION
BEFORE THE

HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY
DEVELOPMENT AND APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

February 27, 1986

Statement of Dr. Donald L. Klass, President, Biomass Energy Research Association, before the House Committee on Science and Technology, Subcommittee on Energy Development and Applications, Hearing on FY 1987 Authorization for the Department of Energy's Biofuels Technology Program, February 27, 1986.

INTRODUCTION

Thank you Mr. Chairman and members of the Subcommittee.

My name is Donald L. Klass and I am President of the Biomass Energy Research Association (BERA). BERA is a non-profit association that was founded in 1982 by biofuels researchers to promote education and research related to the development of biomass energy systems, and to serve as a source of information on biomass policies and programs for our members and industry.

Each year, as we prepare to comment on the federal role in supporting biofuels research, we survey our members' views on the needs for research and development. These comments are directly reflected in the recommendations we are presenting today.

First let me take a moment to commend the Subcommittee for the recognition it has given biofuels research in recent years. Certainly, you have recognized the unique qualities and contributions of biofuels technology. For example, these technologies:

- Provide domestic, renewable substitutes for fossil-derived liquid, gaseous, and solid fuels, as well as electricity, by application of suitable conversion processes.
- Contribute about 3% to the Nation's primary energy demand with wood fuels (1.2 million BOE/d), octane-enhancing alcohol fuels in alcohol-gasoline blends (32,000 BOE/d), electric power from municipal solid waste combustion plants (8,200 BOE/d) and methane from municipal solid waste landfills (2,400 BOE/d).
- Retain in this country, even at a price of $15 per barrel of oil, about $7 billion per year that is not expended on imported energy.
- Provide excellent regional benefits — 80 cents of every dollar spent on biofuels in a given region stays in that region, while 80 cents of every dollar spent on petroleum leaves the region.
- Create local jobs and income such as, for example, the 65,300 jobs and $1.3 billion in income in the Northeast that results from wood energy utilization.

Clearly with relatively modest amounts of federal research support, especially in comparison to other technologies, biofuels are making a significant contribution to the Nation's energy supply. Further, biofuels technology is applicable to the special needs of every region of the Nation.

However, technological barriers remain before advanced biofuels systems can be utilized. These must be addressed with continuing federal support of basic and high-risk research and development because biofuels technologies are the only ones capable of providing energy in all its forms to all our citizens without concern for resource depletion, import problems, and environmental safety.

These highlights demonstrate the substantial benefits to be achieved through continued biofuels research and development. However, new capabilities such as the fermentation of lignocellulosic materials (wood and crop residues) to produce low-cost ethanol fuels, the production of medium-Btu gas at low cost, and the pyrolysis of biomass to produce oil products, offer the potential for enormously increasing the versatility and ultimate scale of biofuels technology in the United States. At the same time, these innovations present complex technical challenges that require the resolution of many problems. It is particularly appropriate that the federal biofuels R&D program continue to maintain funding of biofuels for long-term, potentially high pay-off technologies.

BERA RECOMMENDATIONS

Before I describe BERA's recommended FY1987 funding priorities, let me take a moment to express some concerns that our membership has regarding the Department of Energy's biofuels program.

First our recommendations emphasize the need for continuity of funding research in thermochemical and biochemical conversion. Answering fundamental questions about how various biomass fuels can be processed and efficiently converted is the keystone to a sound program to develop advanced biofuels systems. Yet, this part of the program we believe, has been disproportionately reduced over the last few budget seasons relative to other program elements. We trust the Subcommittee will take this factor into consideration during its deliberations.

Now, I would like to highlight for the Subcommittee some of the key aspects of our recommendations.

Thermochemical Conversion

The thermochemical conversion program has made substantial strides towards its objectives and is just now entering the phase when innovations at the bench scale are being consolidated into meaningful technologies. Reductions in the program at this time would prevent the consolidation of many of these gains. BERA's members engaged in thermochemical conversion research are alarmed at the large reduction in funding for research activities that the program has already experienced.

Research should be continued to develop innovative advanced gasification processes for the economic and reliable production of gaseous fuels from both biomass and municipal solid wastes. Progress has been made on optimization of reactor designs and operating conditions to maximize the desired products. More research is needed to evaluate feedstock conversion characteristics and requirements. Continuing research should also address problems associated with the feeding of solids at high pressures and recycling to improve carbon conversion and to reduce environmental problems.

Although BERA supports funding for prototype testing (on a cost-shared basis with industry), such testing should not detract from maintaining a vigorous thermochemical conversion program component.

Progress has also been made in achieving high yields of substitute fuel oils through the optimization of pyrolysis conditions for maximizing liquid yields. Research and development efforts should continue to improve oil yield and to quantify oil product combustion and storage characteristics.

Overall, BERA recommends $8,900,000 be directed to continue thermochemical conversion research in FY87.

Bioconversion

Bioconversion research has concentrated on the development of technology for the economical use of our vast lignocellulosic resources as feedstocks for fermentation and other bioconversion processes. The resistance of lignocellulose to biological attack and its multi-component make-up continue to present many difficult R&D challenges. The federal biofuels program should continue to address the problems of feedstock pretreatment, sugar recovery and fermentation, by-product recovery and applications development, and wastewater controls. An assessment of biofuels technologies conducted in 1985 rated lignocellulose bioconversion technology as the foremost development need. Again, progress to date is just reaching the point where individual advances in the laboratory are being consolidated into meaningful processes.

BERA recommends that $6,800,000 be directed to continue bioconversion research.

Biomass Production

Biomass production technology development by the biofuels program provides a much needed orientation of cultivation strategies to produce high-yield, low-cost biomass feedstocks. Short-rotation intensive culture tree growth offers a unique way to produce large amounts of woody biomass over shorter periods of time for energy applications. Herbaceous biomass development offers high-yielding energy crops with major soil conservation benefits and new opportunities for the farmer. Aquatic biomass production has proven very constructive as a treatment method for municipal sewage and simultaneous feedstock production. It also has the potential of providing new ways to produce liquid fuels.

BERA recommends that $5,200,000 be directed to continue biomass production research.

Regional Programs

Since the regional programs were instituted three years ago, they have proven extremely valuable in facilitating the transfer of technology to the private sectors in their respective regions. Feedback through the regional programs has also proven beneficial in the fine tuning of the mission-oriented research programs, and has better communicated the utility of the biofuels program to those at the grass roots level. BERA believes the biofuels program can benefit substantially by enhanced communication with universities, industry, and the community of prospective biofuels end-users. The December 1985 report released by the Energy Research Advisory Board also supports keeping a broad base of participation, especially with universities and industry, in the solar and renewable programs.

BERA recommends that $2,500,000 be directed to continue the regional programs.

Recommended Budget

One final consideration in presenting a biofuels budget is the recognition of the challenge to the biofuels program management as a consequence of the consolidation of several previously autonomous programs into a single biofuels program. Although the consolidated biofuels program has strived to sustain the original objectives of the separate programs, it is obliged to do so within the constraints of a steadily reduced budget. Thus, the "critical mass" of individual research initiatives is challenged by both a declining budget and an increase in the total number of research activities. To help overcome these difficulties and sustain an innovative program, BERA recommends the following budget for biofuels technology for FY 1987:

Biomass Production Research	$ 5,200,000
Conversion Research	
Thermochemical (including MSW)	8,900,000
Biochemical (including alcohol fuels)	6,800,000
Regional Programs	2,500,000
Total	$23,400,000

Program Evaluation

The Department of Energy Office of Conservation and Renewable Energy published an evaluation in 1985 to estimate the potential payoff of renewable energy options including biofuels, prioritize R&D objectives over the next 5 years, and identify the Federal Government's role in accomplishing these objectives. This type of comprehensive analysis is extremely important, so much so that BERA recommends that this process be an on-going one and that the results be applied to the makeup of the biofuels program to maximize the Nation's return on this investment. The formulation of a detailed 5-year plan which is updated on an annual basis and its critical review are strongly recommended.

I appreciate the opportunity to appear before you today on behalf of BERA and would be happy to answer any questions you may have now, or later in writing.

Mr. **Fuqua**. Mr. Gray.

STATEMENT OF THOMAS O. GRAY, EXECUTIVE DIRECTOR, AMERICAN WIND ENERGY ASSOCIATION, ACCOMPANIED BY BOB SHERWIN, DIRECTOR, ENERTECH CORP. AND PRESIDENT-ELECT, AMERICAN WIND ENERGY ASSOCIATION

Mr. **Gray**. Thank you, Mr. Chairman. My name is Tom Gray, and I am executive director of the American Wind Energy Association. Accompanying me today is Mr. Bob Sherwin; he is a director of Enertech Corp., which is a leading wind turbine manufacturer, and he's also president-elect of our association. We appreciate the opportunity to testify.

Our association is a trade association representing the manufacturers of wind electric turbines and their components. We have about 250 corporate members; many of them are small businesses, but they also include a few very large corporations, such as Boeing Aerospace.

My testimony is basically organized around three major points.

First, our industry has grown and matured, I think, very dramatically over the last 5 years.

Second, because of a series of economic forces beyond its control that will all come together right about now, our industry is facing a rather uncertain future. And we feel that in this particular situation, a well-designed and well-managed Federal research program could be of great help.

Third, and most importantly, our Federal program must steer a course toward a greater relevance to and cooperation with our industry.

Now, a few words about our growth. You will recall, Mr. Chairman, a few years ago when this committee passed the Wind Energy Systems Act of 1980. I happened to be involved in helping draft that bill; I thought it was a very far-reaching and forward-looking piece of legislation. And it anticipated the possibility that as many as 800 megawatts of wind energy equipment might be installed by the year 1988.

As you know, that legislation has remained largely unfunded in the interim since it was passed. Nevertheless, we have exceeded that total of megawatts installed. By the end of last year we had over 1,100 megawatts installed in California, almost entirely by the private sector; building, of course, on the technology base supplied by the Federal program, the energy tax credits, and other incentives.

We had 10,000 kilowatthours generated by wind farms in California in 1981; actually, it's a little less than two average households that could have been supplied with that energy. Last year, we produced 620 million kilowatthours, which is enough for about 100,000 households. So I think we've made terrific progress.

I've quoted in my testimony from a study prepared by Pacific Gas and Electric Co. for presentation this week at a conference. They document the improvements that are being made in capacity factors on these wind farms, how the equipment is increasing in reliability, and they say, "This is excellent performance for an emerging technology."

I have with me a copy of the entire paper; it's six or seven pages long, and I'd like to offer it for inclusion in the record if the committee desires.

[See appendix, p. 307.]

Mr. **Gray**. As I say, we've gone uphill pretty rapidly but we're facing an uncertain situation today. Some of the factors we face——

Of course the tax credits expired at the end of 1985. You wouldn't have had to be a wizard to predict that, but we really didn't think that at the same time we'd be facing repeal of the basic 10-percent investment tax credit, and also a stretchout of depreciation periods in the same year. That, I think, is going to make it very difficult for our industry to go on doing business in anything like the manner it has previously.

Also, of course, you've heard from other witnesses about the fall in oil prices. We share their concern; since we produce primarily electricity, we're somewhat insulated from the immediate impact economically, but we've certainly felt it politically here on the Hill in terms of people's waning interest in the energy issue.

We expect in this Congress also to see some sort of attempt to restrict or limit the application of PURPA, and that, too, would be very harmful to our industry. We understand the feeling that utilities are in overcapacity situations and shouldn't be forced to buy thousands of new megawatts of power from small producers. But we hope that Congress is going to proceed very circumspectly in that area because it's a key one for us.

We are also, of course, facing cutbacks in the Federal research budget driven by the budget deficit. We have growing regulation in California of the wind farms; they've become a matter of some interest to some of the localities, and that has imposed additional burdens on our industry.

Then, a couple of particular points of interest, I think, to the subcommittee. The Federal program started off with the notion—and so did our industry—that aerospace technology was what really needed to be brought to this industry. Wind/electric technology has been around for quite a while. The machines were too expensive and too heavy, and what you could do is take aerospace advances and just sort of graft them wholesale into this technology and it would really take off, as it were.

The Danish companies, on the other hand, had experience with wind in sort of the realm of agricultural equipment, and they built their machines along those lines; they made them like tractors—big, sturdy pieces of equipment. And as it has turned out, the difficulty of harnessing the wind because of the very difficult physical requirements that it puts on rotating mechanical equipment have given them a definite edge in the early years of development of this technology. We've made a lot of progress, I think, with our equipment, but there were significant differences from aerospace and we've learned that, I guess, to our detriment along the way.

So we stand here today with equipment which is, I think, increasingly reliable; in fact, it's very near to that of the competition, and it's certainly shown potential for being much cheaper, which was the original idea. But we haven't quite gotten there yet, and several of the companies that have taken very risky approaches stand today in financial difficulty and are going to need, I think, considerable assistance in finalizing their machines and getting their designs down to where they can really produce power and not have to be maintained quite as actively as they are at present.

And also generally, the second point is that our equipment really is a little too expensive for a wide market. We have a commercial industry but as you know, there's commercial and then there's real commercial. And at 20 cents a kilowatthour you can compete in some areas of the world for remote power systems where the only choice is diesel power, and it's very expensive. But your total market worldwide may only be a few megawatts. If you can bring that cost down to 5 cents a kilowatthour or lower, why, then you have a much, much broader market where you're competing on a regular basis with conventional energy sources. That, of course, is what we'd all like to see happen in this technology and what we think is achievable.

Now, a third point, to do that—and I was particularly pleased to see the paragraph in Dr. Hubbard's testimony about an industry/Government partnership in this field. That, we think, is very key. The Federal program—I guess I feel that my talent is communications because I'm sort of in the political business, and there certainly, in my view, is not enough communication between the Federal program on a regular basis and industry; not enough interchange of the research results; not enough feedback from the industry as to the problems that they are actually encountering in the field that would help make the research directed into those areas which are fairly complex, but where industry needs help.

I didn't mention in my written testimony, and I certainly should in my oral lest I be taken for forgetting the forest for the trees, the overall total of $8.25 million that's being proposed by the administration that represents a modest two-thirds cut from last year's congressional appropriation, we think, is totally inadequate. We are ready, as this committee has suggested, if need be to accept the 15-percent reduction that Gramm-Rudman would require across the board. But we think going further than that would not be justified, particularly in view of the current status of the technology. And I should note here also the irony that a few years ago, when we passed that Wind Energy Systems Act, we were ready to throw several hundred million dollars at this technology, and we had no notion then that what would come out of it would actually be something. Today we know that there really is a viable energy-producing technology that can be quite competitive with conventional sources, and we're cutting down from $20 million to $8 million. It just shows you how things can change in a few years.

So our recommendations on what might be done with the program—we have a number of very specific ones. We chose to do it that way, and then just list out our proposed budget totals at the end. And I'm going to touch, I guess, on just a few of the high spots and say that we would like to see some new initiatives. First of all, we'd like to see the Cooperative Field Test Program expanded. That's right in the neighborhood of an industry/Government partnership. It involves the Government asking industry for test proposals in areas that are of interest to the Government that they feel are areas that are not well understood, and industry coming in with those. They put out the first RFP and got quite a few responses back from industry; we were only able to fund a few of them. We would like to see that program expanded.

We would also like to see an additional initiative that would be a cooperative research program that would go after some other areas that aren't quite susceptible to field testing, like advanced materials fabrication, research in those areas where specific companies are running into problems that are just totally beyond their resources to try to deal with.

We would like to see an initiative—well, there already is one, but we'd like to see it greatly strengthened—in the wind diesel research area. There are millions of diesel units installed around the world for remote power uses, and we would like to see a significant effort to tie wind systems to those diesel generators, help them save fuel. We think there's a very large international market in that area if the research can be done to make the equipment cost-effective.

SERI has just begun a university research program after several years of circling the wagons in the face of budget cuts. We think that's a good initiative, and we would like to see that strengthened to the degree that it's budgetarily possible—that previous university programs have developed quite a few of the engineers that are present in the industry today and that engineering base is a vital component of any industry.

And I'd like to just conclude by saying that I join my counterparts from the solar industry in wanting to thank this committee. It's been a real leader in the fight to develop these technologies, and we're very much aware of that and very appreciative. Without your help, we certainly wouldn't be here today.

Thank you.

[The prepared statement of Mr. Gray follows:]

TESTIMONY OF TOM GRAY
EXECUTIVE DIRECTOR
AMERICAN WIND ENERGY ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
U.S. HOUSE OF REPRESENTATIVES

February 27, 1986

TESTIMONY OF TOM GRAY
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U.S. HOUSE OF REPRESENTATIVES
February 27, 1986

Mr. Chairman and members of the subcommittee, my name is Tom Gray, and I am Executive Director of the American Wind Energy Association (AWEA). Accompanying me today is Mr. Bob Sherwin, who is a director of Enertech Corporation, a leading wind turbine manufacturer, and who is also President-Elect of AWEA. We appreciate the opportunity to testify.

AWEA is a trade association which represents the manufacturers of wind electric turbines and components. About 250 companies are members of AWEA. Many of them are small businesses, but they also include a few large integrated corporations such as Boeing Aerospace Corporation.

My testimony today will be aimed at documenting three major points:

1. The wind energy industry has grown and matured dramatically over the past five years.

2. Because of a series of economic forces beyond its control, the industry today faces an uncertain future. In this situation, a well designed and managed federal research program can be of great help.

3. The federal program must steer a course toward greater relevance to, and cooperation with, the wind energy industry.

Let me elaborate on these points.

1. The wind energy industry has grown and matured dramatically over the past five years.

Our industry is just ending a period of sustained and dramatic growth in the state of California, based on federal and state tax incentives, the Public Utility Regulatory Policies Act of 1978 (PURPA), and the technical data base supplied by the federal program.

The numbers tell a remarkable story.

From installed generating capacity of 7 megawatts at the end of 1981, wind energy has risen to 1,120 megawatts installed today. That is a particularly impressive number when we recall that when the members of this subcommittee had the foresight some years ago to support the Wind Energy Systems Act of 1980, the goal set out for a multi-year federal program to spur wind energy was 800 megawatts of installed capacity by the year 1988.

Only 144 wind turbines were installed in California in 1981. Today, there are over 13,000.

In 1981, wind machines generated 10,000 kilowatt-hours in California -- or less than enough to meet the needs of two average households. In 1985, wind electricity rose to 620 million kilowatt-hours -- enough to serve over 100,000 homes.

The picture is similar in terms of barrels of oil saved. In 1981, just 16 barrels would have had to be burned to produce the amount of electricity generated by windfarms in California. Last year, that total soared to over one million barrels.

The industry's growth has been matched by a simultaneous maturing and development of wind energy technology -- and by way of background, let me explain here parenthetically that harnessing the wind has proven to be a surprisingly difficult technical challenge.

The force which the wind exerts on an object in its path is a function of the cube of the wind speed, so that the forces working on a wind turbine increase geometrically as the wind rises. Also, the wind is often very turbulent, changing direction and speed quite rapidly. For example, a doubling in speed (from 30 to 60 mph) and change in direction of 45 degrees in less than one second is not uncommon.

This high variability means that a wind turbine operates in a very difficult environment which was not originally well understood:

o It was originally thought that the aerodynamics of helicopter blades and propellers would be readily applicable to wind systems. That has not proven to be the case. Wind turbines are different and require different airfoils.

o Early analyses assumed that the wind's flow would be relatively laminar (i.e., smooth) in nature. That, too, was mistaken. The stresses, or physical loads, which a wind turbine undergoes in actual operation were often several orders of magnitude greater than those predicted by engineers.

o Fatigue remains one of the most elusive and difficult problems in wind system design. Wind turbines rotate tens of millions of times during their design lifetimes, and fatigue information for many materials on such high numbers of cycles did not exist a few years ago.

Despite these obstacles, we have made progress, and we are proud of that progress.

Let me illustrate that progress not by quoting from industry sources, but from a major utility, Pacific Gas & Electric Co. (PG&E).

A PG&E study of the more than 5,000 wind machines installed in Altamont Pass near San Francisco was presented this week before the American Society of Mechanical Engineers in New Orleans. In that study, PG&E looked at the bottom line: the capacity factor achieved by the turbines.

[Capacity factor ranges from zero to 1.0, and is the actual output of a generator divided by its hypothetical output running all the time at full capacity.]

PG&E's study showed the following results:

"Based on projections made in November 1985, the 1985 capacity factors for the farms under consideration will range from 0.13 to 0.25, with 0.19 being the overall figure. This compares with a capacity factor for these farms of 0.03 in 1982, 0.05 in 1983, and 0.12 in 1984. This impressive performance improvement was shown in Figure 5.

"How does this capacity factor compare with the projections made by the developers? The wind farm prospectuses have been examined and they project annual capacity factors of from 0.20 to 0.34, with 0.27 being the weighted average...Thus the 1985 achieved capacity factor of 0.19 will be 70% of the wind farm projections...

"This is excellent performance for an emerging technology..."

2. Because of a series of events beyond its control, the industry today faces an uncertain future. In this situation, a well designed and managed federal research program can be of great help.

Let me briefly review these events.

o First, the federal energy tax credits expired December 31, 1985. AWEA lobbied hard and unsuccessfully for phasing out the credits rather than ending them abruptly, and we were supported by many members of this subcommittee. We did so because we felt that industry should have a chance to adjust to a major change in its financial environment.

Most unfortunately, the Ways and Means Committee not only voted not to extend the energy credits, but to repeal the 10% investment credit and to stretch out depreciation for wind systems as well. That is a blow that industry had not foreseen, and that puts its future seriously in jeopardy.

o Oil prices have dropped sharply in recent weeks. This is not directly harmful to our industry, because the connection between oil prices and electricity prices is tenuous at best. But the sudden availability of cheaper oil has greatly eroded political backing for renewable energy in the Congress.

o It is our understanding that an effort to restrict the application of PURPA can be expected during the present session of Congress. Since PURPA requires utilities to purchase the electric power produced by windfarms and wind machines, its continuation is vital to the well-being of our industry.

o The federal wind energy research budget, for reasons with which we are all familiar, is being cut back at a time when other countries, in particular Denmark and the Netherlands, are increasing government support for their wind energy industries.

o California and its counties are beginning to regulate windfarm activity more closely. In some cases, responsible decisions have been made which should allow orderly growth. In others, excessive burdens are being placed on an industry which is still relatively new and small.

To these factors which are mostly outside the industry's control and create doubts today about its future must be added one more.

Both American manufacturers and the U.S. federal wind energy program were strongly influenced initially by the notion that wind systems could be made most economical by incorporating advances in materials and aerodynamics from the aerospace industry.

Our chief world competitor, the Danish wind industry, chose instead to draw upon its own past experience in the use of wind machines as agricultural equipment, making them sturdy, bulky and heavy.

Thus American machines today tend to be much lighter and more technically advanced than Danish turbines. However, because of the unexpected problems with the wind discussed earlier, they have also been much more prone to failure and have required substantially more maintenance.

Although it seems clear that American wind systems have the potential to be cheaper than Danish units, that potential is still some distance from being realized, and the higher reliability of Danish machines has made it easier for them to obtain financing.

A well-designed and managed federal wind research program can do much to assist our industry in this difficult period.

o To deal with the problems posed by the loss of the tax incentives and falling energy prices, more must be done to reduce the cost of wind machines. There are a number of high-risk strategies for cutting production costs, but for the most part, they are beyond the financial capabilities of American wind turbine manufacturers. The federal program could investigate these strategies.

o The federal program can also assist industry in dealing with regulatory problems by continuing to support the development of voluntary consensus standards of a high technical quality, and by investigating very complex and poorly understood issues such as windfarm noise. Again, this is something that is beyond the resources of our industry.

o The federal program can help American industry penetrate its most promising international market, the remote power systems market, by upgrading and pushing efforts to develop wind-diesel and other hybrid systems and by continuing to support renewable energy export activities of the Department of Commerce.

3. The federal program must steer a course toward greater relevance to, and cooperation with, the wind energy industry.

It is the strongly held opinion of our Association and the companies it represents that only a strong and active government-industry partnership will make it possible for American industry to actively compete in the world market for wind energy which is developing today.

We understand and accept the Administration's view that government research activities should be limited to areas that are beyond the capabilities of the private sector. But within those constraints, we feel there is much room for improvement.

With those guiding principles in mind, AWEA presents the following observations and recommendations:

In general, it is clear today that the hoped-for utility market for multi-megawatt wind systems is still some years away, and that there is little possibility that in the near future, the private sector will see any reason to spend the huge amounts of money needed to bring a commercial multi-megawatt system into being.

o **AWEA recommends: 1) Immediate cessation of testing of the MOD-2 2.5-MW wind machines at Goldendale, WA, with FY 1986 funds; 2) Immediate cessation of testing of the WTS-4 4-MW wind turbine at Medicine Bow, WY, with FY 1986 funds.**

Nevertheless, such a large percentage of the funding for fabrication, installation and testing of the MOD-5 advanced multi-megawatt system has already been appropriated and spent that the project should be completed.

o **AWEA recommends: 1) Rejection of DOE's deferral of FY 1986 funds appropriated by the Congress for completion of the MOD-5; 2) Authorization of additional funds in FY 1987 or in future years, depending on the total funds available, to test the unit (not to exceed $5 million total); 3) No further expenditure of federal funds on the machine (beyond those for testing) in the event of mechanical failure; 4) Cessation of efforts to develop a multi-megawatt system following testing of the MOD-5.**

Virtually all DOE research and testing activities can and should be carried out on wind turbines currently installed in windfarm development areas rather than special testbeds at arbitrarily chosen locations.

o **AWEA recommends: Closeout of testing on the MOD-0 test machine following the current program of testing with the cycloconverter. Any further testing of machines in this size range should be carried out on turbines in the field via cooperative agreements with manufacturers or windfarm developers.**

Commercial activity using the Darrieus vertical-axis design has slowed. Only one company is now actively pursuing the design (a second is reorganizing under Chapter 11) and a less ambitious research timetable is more appropriate. Also, Canada's continuing vertical-axis wind turbine (VAWT) program will be a source of research information for this segment of the industry.

o **AWEA recommends: Scaling back the pace of research on vertical-axis systems.**

DOE has recently begun a Cooperative Field Test Program (CFTP), under which testing in support of research goals is pursued on windfarm turbines with cost-sharing by private companies. There is a great deal of industry interest in this program, although the initial funding has been quite limited.

o **AWEA recommends: Expansion of the Cooperative Field Test Program.**

However, AWEA is concerned about the testing of wind systems built by foreign manufacturers in the CFTP. We realize that the presence of a major U.S. utility in the two projects with foreign machines is a major plus, and that the results of the research are in the public domain. Nevertheless: research on foreign equipment should be the responsibility of foreign governments. More than half of the wind equipment sold in the U.S. this year will be foreign-made. Our market is open to the competition, and we do not need to give them further assistance.

o **AWEA recommends: No further proposals for the CFTP that involve testing of foreign wind systems be considered.**

Also, the CFTP is limited to objectives that can be attained by field testing. A number of the problems which wind companies face involve other types of research, such as experimentation with advanced techniques for the fabrication of composite materials. Others, such as structural problems involving machine-tower interactions, require such extensive analysis and engineering expertise that they are generally beyond the companies' ability.

o **AWEA recommends: 1) Establishment of a Cooperative Research Program, with a similar structure to that of the CFTP (i.e., cost-sharing, cooperative agreements of limited size, spread among a variety of companies); 2) Establishment of a Design Assistance Center, which would assemble a core of expertise and data on particularly complex and esoteric areas of wind turbine design such as structural dynamics and provide assistance to industry as needed.**

Now that the expansion of the windfarms is slowing due to the reduction of tax incentives, other markets will become much more important. Of particular interest is the overseas remote systems market. A number of countries have begun wind-diesel research programs aimed at developing wind and hybrid systems which can be sold in this market.

o AWEA recommends: 1) Expansion of the federal wind-diesel initiative, with concentration, in the initial phase, on development of retrofit packages which will make it possible to convert common lines of diesel generators to hybrid wind/diesel systems; 2) Broadening of the scope of the wind-diesel work to include smaller and simpler remote packages that do not require electronic control units and that would use wind systems in a size range where the U.S. has a technical edge; 3) Coordination of the wind-diesel program with federal overseas development initiatives; 4) Continued support for the renewable energy export activities of the Department of Commerce.

Increasing regulation of the industry by local governments has made the need for authoritative industry standards clear. Since the vast majority of the wind energy equipment in the U.S. is installed in just three California counties, local regulators can have a disproportionately large influence on the industry's current and future ability to do business.

o AWEA recommends: Continuation of DOE support for the development of voluntary industry consensus standards to provide guidance needed for sound and responsible regulation.

Cutbacks in the federal wind program in recent years have led to cancellation of most of the research grants to universities, and that in turn has led to a shortage of trained wind engineering personnel. The Wind Energy Research Center has recently initiated a small university research program that has attracted considerable university interest.

o AWEA recommends: Continuation of the university research program and its expansion as budgetary constraints permit.

Mr. Chairman, this concludes our recommendations for changes in the federal wind energy research program. The subcommittee has requested that we provide a recommended allocation of funds for the program at a level reduced 15% from the FY 1986 appropriation. Such a reduction would mean a budget of about $20.5 million, and our recommendations for funding at that level are provided in Attachment 1. We also include in Attachment 1 our recommendations for funding at the level of $8.25 million requested by the Administration.

Again, we thank you for the opportunity to present our views, and we look forward to working with the subcommittee to develop a sound and useful wind research program.

ATTACHMENT 1

AWEA Wind Research Budget Recommendations

Program	$20.5 million	$8.25 million
Cooperative Field Test Program	$3.0	$2.25
Cooperative Research Program	1.0	1.0
Wind/Diesel and Remote Power Systems Research	3.0	1.5
Standards	0.15	0.15
University Research	3.0	0.7
Aerodynamics	1.7	0.5
Structural Dynamics	2.0	0.8
Resource Assessment	2.0	0.7
MOD-5 Testing	4.5	0.5
Capital Equipment	0.15	0.15
Total	$20.5	$8.25

Mr. **Fuqua**. Thank you very much, Mr. Gray.

Let me ask you and Dr. Klass your thoughts about the cooperative R&D venture program that was discussed earlier today, and what inducements might be necessary to translate some of the basic research and the applied research into commercial reality between the two groups that both of you represent?

Mr. **Klass**. Well, I think that's an extremely important question which can't be answered over just a few minutes, but let me point out that getting industry involvement in some of these cooperative programs, right up front, is going to probably spell the difference between commercial success and commercial utilization of the technology that's developed, and failure.

So I think that should be done very early in the game. They should be involved in operating the program, being requested to provide information regarding their thoughts on the direction that technology is taking, and all in all, play an important role in the overall research and development function.

Now, the inducements that might be provided, I think some of them are already under way in the biofields industry. In the municipal solid waste category, many industrial organizations have invested in R&D on their own, have worked with various associations, trade and professional, and also the Federal programs to try to commercialize further advanced municipal solid waste-to-energy projects. It's the biomass area that is going a little slower, even though that is the major contributor to energy consumption today in the biofields area.

One of the things that I think could be expanded in the regional programs is the workshops that would get the industrial organizations involved in communicating with the people who are doing the R&D. I think perhaps this might be classified as an inducement. If the regional programs are zeroed out, as they are in the fiscal year 1987 request from DOE, there will not be any further inducement of this type that might be offered to attract industry participation.

I think there are quite a number of other inducements, too, that might be provided.

Mr. **Fuqua**. Mr. Gray.

Mr. **Gray**. Well, I guess I would say with respect to the cooperative ventures, that we would be very interested in exploring that area and seeing what could be done. I was pleased to hear Ms. Fitzpatrick say that considerable industry participation would be needed in trying to figure out exactly how it would work, because I join with Mr. Klass in feeling that that's very important.

We're a little concerned—you know, the business of companies joining together in cooperative ventures—some of our companies would like to do that; others would not. They feel they are way ahead of everybody else, and so that is an issue that would have to be addressed and there would be some—probably a few thorny issues to be worked out.

But, you know, the thrust of our testimony is toward trying to bring the industry and Government closer together, and we feel strongly about this and we would try to view this in that light and cooperate with it.

Mr. **Fuqua**. Dr. Klass, in the biofuels programs, it supports both the feedstock production and also the conversion process, and it's my understanding that many of the colleges and universities are presently engaged in feedstock production. And I'm interested in what role you think that DOE should have in trying to coordinate the feedstock production, and also engaging in the conversion process research?

Mr. **Klass**. I think DOE's role in a coordination capacity, as far as feedstock production research, is an important one. They should continue to fund a certain portion of the program on feedstock production research because, without the development of optimum biomass feedstocks for conversion processes, there will of course be no commercial biofuels technology in the biomass category that will result from this effort. So a certain portion of the funding should be devoted to that.

Their role, as far as coordination, is one that I would view as one of communications with all of the organizations that are doing the production research. The USDA should be included in, let's say, the inner workings of the agencies within the Government; there should be complete cooperation and communication and exchange of information, particularly biomass production research of all types; that is, the land-based, the aquatics, and the marine biomass production biomass activities that are in progress.

As far as conversion research, I think they're doing a pretty good job of coordinating this work now. Communications are certainly meeting with my satisfaction in the work that has been done. I think that probably more dissemination programs of the information that has been developed and generated over the recent 2 or 3 years could be incorporated in what they're doing to improve matters somewhat, but as I referred to regarding industry/Government cooperation, I think early participation by industry in both production and conversion research will result in a higher success rate of commercial utilization of this technology.

Mr. **Fuqua**. Dr. Hubbard, you talked some about the money, and I understand that the fiscal year 1986 budget for SERI is $62.26 million?

Mr. **Hubbard**. That's approximately correct.

Mr. **Fuqua**. And the estimates that we have this year for 1987 are about $41.8 million.

Now, what is the impact of that going to be on SERI?

Mr. **Hubbard**. Mr. Chairman, that $41.8 million figure, I had not heard before so guidance has not been provided to me; and therefore, we haven't really had a chance to discuss that with DOE as to how they perceive that or how we should react to it.

Mr. **Fuqua**. Yes. That was some information they gave us; I assume it's a reasonably accurate figure.

Mr. **Hubbard**. I have no reason to challenge it; I simply have not——

Mr. **Fuqua**. Well, what impact would the approximately $20 million have?

Mr. **Hubbard**. It would depend, of course, on how much latitude we had in dealing with it and what the priorities were perceived to be. It would certainly seriously change—or significantly change—SERI's role in the things we are able to do. Our internal budget or internal costs are approximately $43 million. Thus, $42 million devoted to running SERI internally, is a number that we could deal with all right; but that would imply that the subcontracting work is essentially zero, which is probably not a practical or useful or highly desireable thing to do. So it would require a considerable amount of discussion and scrambling around, some really hard decisions on our part and some really hard decisions on DOE's part.

Mr. GRAY. Mr. Chairman, could I just interject something on that?

Mr. FUQUA. Mr. Gray.

Mr. GRAY. I'd just like to say that with respect to the wind program at SERI, we are quite concerned about the limited staff that they have available. As you know, NASA is being withdrawn or is withdrawing, whichever you want to take, from the large wind program and the management of that has been put into the SERI Wind Program. And additional staff, I think, for the most part has not been made available. So we are real concerned about the thinning of the ranks there and hope that the committee takes that into consideration.

Mr. FUQUA. Also, Dr. Hubbard, we realize you are still quartered in temporary facilities—or leased facilities, I guess, is probably a better word.

Mr. HUBBARD. About 75 to 80 percent of the staff is in leased facilities.

Mr. FUQUA. And has the lack of a permanent facility affected your ability to continue to carry out high quality research?

Mr. HUBBARD. I think it has increased the cost of what we do. Leased facilities are marginally more expensive in and of themselves, but in particular, the laboratory facility was not designed for research. So when you have to change anything, it takes an inordinately long period of time and it costs more money than it would in a building that was designed for laboratory research in the first place. We can operate in it and we do operate in it, but at some cost, therefore, and there are some limitations in the design of the building which do inhibit the kinds of things we can do in it. In photovoltaic research, you handle some pretty noxious materials, highly toxic; and handling those materials in a building of that design in an area in which you're close proximity with both residential housing and with office housing is a subject of concern to us.

Mr. FUQUA. DOE indicated in their—or, OMB—in the passback to Department they said, "The annualized penalty for leasing rather than having your own building is only about $50,000 a year." Would you concur in that? That's the penalty for leasing versus owning.

Mr. HUBBARD. I don't have a personal view on it, and SERI has not made a study of it in and of itself.

I understand there were two studies done. One was done by DOE in which they used the 7-percent discount rate. And with the 7-percent discount rate—we're talking about two buildings, now, an office building and a laboratory building—total savings were more like $240,000 a year.

Mr. FUQUA. To own your building?

Mr. HUBBARD. Yes.

I think there's been another study done at a 10 percent discount rate, and probably that's the one that OMB is referring to, I suppose.

Mr. **Fuqua**. Mr. Walgren.

Mr. **Walgren**. No questions, Mr. Chairman.

Mr. **Fuqua**. I want to thank you gentlemen very much for being here today. We appreciate your testimony and help.

Mr. **Hubbard**. Thank you, Mr. Chairman.

Mr. **Gray**. Thank you.

Mr. **Fuqua**. We may have some additional questions to submit to you in writing, and we'd appreciate your cooperation in answering them.

[Additional questions and answers follow:]

Solar Energy Research Institute
1617 Cole Boulevard
Golden, Colorado 80401
(303) 231-1000

SERI

RECEIVED
MAR 19 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

March 18, 1986

The Honorable Don Fuqua
Chairman
Committee on Science and Technology
U.S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, DC 20515

Dear Mr. Chairman:

Thank you for the opportunity to testify on February 27, 1986, before the Subcommitee on Energy Development and Applications.

In response to your letter of February 28, 1986, I enclose my answers to the additional questions posed by members of the Subcommittee. Again, thank you for the opportunity to testify and to provide responses to these questions.

Sincerely,

H. M. Hubbard
Director

ks

Enclosure

A Division of Midwest Research Institute

Question No. 1

What benefits, disadvantages, and technical impediments are involved in merging the Solar and Conservation Building programs?

Since SERI has performed only a limited amount of work for Conservation, and therefore does not have detailed knowledge of its programs, we are not able to provide the Subcommittee with a fully responsive answer to the question. DOE would be in a much better position to address this question because they have a better understanding of the programmatic and organizational issues involved.

The two programs are complementary. The researchers involved in the field appear to be in good communication on technical issues. I see no technical impediments to combining the programs. If buildings are considered as systems, as they should be, it is clear that the two programs must be either closely coordinated or managed as a single unit.

If the programs were to be combined at this point, given the fact that they have been administratively separate since their beginning, care must be taken to see that the change is not disruptive and that the management of the combined program has a broad perspective encompassing both the energy supply and energy conservation approaches.

Question No. 2

One of our witnesses has suggested that DOE place the Solar Energy Research Institute in its own line-item. It is claimed that this would provide greater stability for SERI and would provide Congress and the solar industry with an up-front view of how the program research pie is divided. Please comment.

We have considered the suggestion to make SERI a single line-item in the budget. While some other agencies fund laboratories in this manner, none of the DOE laboratories are funded on a line-item basis. Thus, there is no operating experience to draw upon to determine how well this concept would actually function in the DOE organization.

The apparent thrust of the question, to provide greater stability for SERI and to provide Congress and the solar industry with an up-front view of how the program research pie is divided, could be achieved by Congress asking DOE for a report in their annual budget submissions delineating the funds by program that would go to SERI. The Committee may also wish to ask that a study be conducted to more fully assess the feasibility of this concept and to arrive at the proper balance between line and program funding.

One disadvantage that has come to our attention is the impact that the Gramm/Rudman/Hollings legislation might have on SERI if it were a single line-item. We understand that DOE would be required to apply the full reductions required by this legislation to any part of SERI that was funded as a budget line-item. If this interpretation is correct, DOE's flexibility to make adjustments based on program priorities would be more limited than it is at present.

Question No. 3

The December 1985 ERAB Solar Panel report recommended noted that "(t)o assure the integrity of the newly consolidated planning and analysis functions at SERI, provisions should be made to assure continued broad participation in the process, including industry, universities and other laboratories. Analytical objectivity needs to be assured by separating the research and analytical activities." How is SERI implementing this recommendation?

SERI agrees completely with this aspect of the ERAB report. It has been a continuing concern of both DOE and SERI as we move together to establish the analytical support functions recommended in the report. The approach proposed by SERI would place the SERI analytical support function in the immediate office of the SERI Director, with the mission of supporting the needs of the program as defined by the Deputy Assistant Secretary for Renewable Energy. Liaison for each solar technology will be sought with the full range of knowledgeable and concerned individuals within federal laboratories, universities and industry. This will be carried out directly and through the several programmatic long-range planning activities housed at SERI. We feel that this arrangement provides for analytical objectivity, by organizationally separating the analysts from researchers, but also provides good access to accurate information, essential to effective analysis.

Question No. 4

On February 12, the Department submitted to Congress its FY 1987 funding estimates for individual laboratories. The DOE estimate for SERI totals $41.82 million as follows: $2.4 million for Solar Building Energy Systems, $17.25 million for Photovoltaic Energy Systems, $5.4 million for Solar Thermal Energy Systems, $5.765 million for Biofuels Energy Systems, $5.7 million for Wind Energy Systems, $2.2 million for Ocean Energy Systems, $1.4 million for Solar Technology Transfer, $0.545 million for GPP and GPE, $0.5 million for Solar Resource Assessment, $0.1 million for Solar Program Support, $0.15 million for Energy Storage Systems, and $0.4 million for Policy and Management. What would be the impact of such a budget reduction on SERI?

in response to this question, when I appeared before the Subcommittee, I testified that the reduction in funding represented by the FY 1987 estimates for SERI provided to the Congress by the Department would certainly have a significant impact on SERI institutionally and programmatically. Given the estimated internal costs for the operation of SERI in FY 1986 of $43 million, and that we receive some funds from the DOE Office of Energy Research (which I presume are not included in the estimates) and other agencies, totalling about $2 million, it is apparent that the estimated funding could maintain SERI's present level of internal activity. To do so would require the virtual elimination of SERI's subcontracted research with universities and industrial laboratories—something which is neither practical nor desirable to do. Also, the mix of estimated funds would imply some rebalancing of research activities and staff. What would be required is a balanced reduction in both in-house and subcontract activities.

Since we have not had an opportunity to discuss the estimates and their implications with the Department, I cannot provide the Committee with a detailed accounting of the impact. An idea of the program elements affected and the extent of the impact can be obtained from the attached table. The dollar variances of FY 1987 estimates from FY 1985 (actual) and FY 1986 (based on latest DOE guidance) new budget authority are also shown in the attached table. The overall reduction compared to FY 1986 is 22.4% with reductions ranging from 0% to 44% among the various programs. We need to have detailed discussions with DOE officials to determine how the reductions would be applied within the program elements, how the in-house vs. subcontracted work might be affected, and the degree of flexibility that exists to modify the estimates cited in your question.

DOE/SERI SOLAR ENERGY BUDGET
(Dollars in Millions)

Technology	DOE Solar Appropriation FY1985	SERI Authorized Funds FY1985*	DOE Solar Appropriation FY1986*	Estimated SERI Authorized Funds FY1986*	DOE Solar Proposed Budget FY1987*	Testimony Projected SERI Funds FY1987*
Solar Buildings	$ 9.185	$ 2.760	$ 8.181	$ 2.380	$ 4.700	$ 2.400
Photovoltaics	46.169	21.430	40.678	24.586	20.600	17.250
Solar Thermal	33.895	7.200	25.885	7.176	15.300	5.400
Biofuels	30.031	7.585	27.326	6.600	12.200	5.765
Wind	28.355	7.008	24.825	6.505	8.250	5.700
Ocean	4.008	3.540	4.811	2.040	2.500	2.200
Resource Assessment	—	—	0.962	0.769	0.700	0.500
Solar Technology Transfer	5.100	3.110	2.983	2.492	2.000	1.400
International Solar	0.500	—	0.962	—	0.500	—
Program Support & Direction	5.864	—	5.767	0.450	4.997	0.500
TOTAL SOLAR OPERATING	**$163.107**	**$ 52.633**	**$142.380**	**$ 52.978**	**$ 71.747**	**$ 41.115**
Energy Storage Systems	**18.642**	**0.050**	**17.292**	**0.150**	**8.600**	**0.150**
SERI General Plant Equipment	—	—	0.251	0.251	0.315	0.315
SERI General Plant Projects	—	—	.993	1.993	0.230	0.230
TOTAL SERI GPE and GPP			**$ 2.244**	**$ 2.244**	**$ 0.545**	**$ 0.545**
TOTAL	**$181.749**	**$ 52.683**	**$161.916**	**$ 55.372**	**$ 80.892**	**$ 41.810**

* Program totals include operating expenses and capital equipment but not construction dollars

BERA Biomass Energy Research Association

RECEIVED
MAR 17 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

March 14, 1986

The Honorable Don Fuqua, Chairman
House Committee on Science & Technology
2321 Rayburn House Office Building
Washington, DC 20515

Dear Congressman Fuqua:

My written response to the two followup questions in your letter of February 28 is enclosed. On behalf of BERA, I would like to thank you and the Subcommittee for the opportunity to present our testimony on February 27. If you or Dr. Watsson have any further questions, please do not hesitate to contact me.

Sincerely yours,

Donald L. Klass

Donald L. Klass
President

DLK/clv

Attachment

cc: Dr. Harlan Watson

1825 K Street, N.W., Suite #218, Washington, D.C. 20006 • (202) 785-2856

RESPONSE TO QUESTION #1:

Cost-sharing of bench-scale and pilot plant projects can be an effective way of increasing commercial use of a project's results. There are many inducements that DOE can provide to industry to attract co-funding support. Some of the most important ones are:

Awareness:

- Keep industry informed every step of the way by direct discussions, workshops, reports, etc.
- Produce and distribute success stories as fact sheets that present the technical, social, and economic benefits of commercial biofuels projects.
- Carefully compile a very selective list of potential industry co-sponsors for each category of R&D and make certain that these organizations receive the proper information as hardcopy.
- Contact each potential co-sponsor to ascertain that the material was received, and discuss their interest.
- Invite specific industries to cost-share and spell out benefits.

Participation:

- Determine specific perceived needs of selected potential industry co-sponsors and make sure their needs are addressed in R&D plan.
- Invite selected industries to have inputs on a project as early as possible, even in its selection for funding.
- If they wish, invite industry to provide working staff for a project at their own expense (one form of cost-sharing).

Economic Incentives:

- Extend and improve biomass energy tax credits and forgiveness.
- Target improved economics as an R&D objective for processes and integrated systems, particularly those that are almost economically competitive now.
- Find and develop site-specific biofuels projects that are economic now.
- Provide assistance in financing commercialization through loans, price guarantees, and other methods.

- Develop simplified investment-planning packages to assist potential industrial co-sponsors in evaluating a given project in the R&D stage.

- Give an industrial firm that cost-shares a temporary period of exclusivity on the technology, possibly even patent rights if the cost-sharing is large enough.

- Develop a graduated scale of benefits for an industrial firm that cost-shares, i.e., the earlier and the larger the cost sharing, the greater the benefits.

RESPONSE TO QUESTION #2:

BERA was not involved in the 1985 evaluation of renewable energy options conducted by DOE's Office of Conservation and Renewable Energy, but the results of the assessment were carefully analyzed by BERA's officers. The analysis was helpful in many ways, and we strongly recommend that it be continued. Some of the major benefits to BERA's members, those involved in biofuels R&D, and those in the private sector who are potential users of the technology are:

- The program managers were personally required to prioritize project areas and individual projects. This will help management perform its function better provided the results are actively used.

- Individual projects and entire renewable R&D program areas, for example, biofuels and wind energy, can be compared with each other to help select R&D targets. Since there are numerous routes to individual objectives in biofuels R&D, those projects that should not be supported can be culled out, and those that have a high probability of meeting management's objectives can be retained. New proposals and ideas can be partially evaluated by the methodology to assess the Federal role, the proper funding level, and whether the project goals can be met in a given period of time. The assessment method is one of several project ranking tools.

Because of the wide range and multiplicity of project possibilities in biofuels R&D, all projects cannot be supported because of budgetary constraints. The prioritization of biofuels projects, if done at least annually to generate and update a 5-year plan that is subject to scrutiny by DOE and others, will help ensure a greater return on the R&D investment for the Nation because the value of a mission-oriented project can be assessed before the project is initiated, and progress on each project can be semi-quantitatively evaluated during its conduct.

It should be emphasized that the evaluation conducted in 1985 was a first-time effort. The methodology used is undoubtedly subject to revision to improve objectivity in project assessment and ranking. At the same time, the methodology should not result in a strictly mechanical process of project ranking, and thereby stifle creativity, and innovative ideas. Provision should be made for pursuit of new concepts and basic research that may not be mission-oriented at the beginning. Nevertheless, a project merit ranking system is sorely needed to increase commercial utilization of biofuels R&D results.

American Wind Energy Association

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California Wind Energy Association

Paul Vosburgh
VAWTPOWER, Inc.

March 30, 1986

Honorable Don Fuqua
Chairman
Committee on Science and Technology
2321 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Fuqua:

Enclosed is my response to your letter of February 28 concerning additional questions from the Subcommittee on my testimony of February 27.

I apologize for the delay in getting back to you, which was occasioned by the recent birth of my first child.

I hope this information is helpful.

Sincerely,

Thomas O. Gray

Thomas O. Gray
Executive Director

1017A King Street, Alexandria, VA 22314 USA   Tel. (703) 684-5196   Telex 275445 TSI UR

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Conservation and Renewable Energy

Responses to Followup Questions

Thomas O. Gray

1. What size market and under what conditions would you see the future for a multi-megawatt wind turbine?

The size of the market for multi-megawatt wind turbines, or those of any size, is a function of (1) world oil prices and (2) utility electricity prices.

Both General Electric and Lockheed, in mission analyses for the Department of Energy, found that wind electric turbines could potentially supply 1 trillion kilowatt-hours of electricity annually -- an amount equal to 40% of current U.S. electricity demand -- taking into account constraints on available land and other limiting factors.

GE's study suggested that this energy could be produced by 313,500 1.5-MW wind turbines. The total installed cost of those units, using their cost estimates, appears to be a little over $100 billion.

However, there are two major issues that must be resolved for the development of this market, and that constitute the "under what conditions" part of my response.

First, world energy prices must rise sufficiently and steadily enough for major corporations to feel they will realize a large enough return to make the investment to develop a commercial multi-megawatt turbine worthwhile. American businesses today have a short planning time horizon, and they need to see returns on the bottom line quickly. The prospects for eventual development of a profitable wind turbine market are still excellent today, but the fact that that market may not develop for several more years has caused the major corporations working on wind to look for more profitable and near-term investments instead.

Second, it is possible that intermediate-scale machines, sized from 100 kW to 1 MW in size, may become the technology of choice.

The Electric Power Research Institute has expressed the view [see "Wind Power: A Question of Scale," EPRI Journal, May, 1984, copy enclosed] that intermediate machines may have a cost advantage over larger systems because they are less complex and can be installed without special equipment.

My own view is that multi-megawatt systems will eventually be developed, but as a logical extension of intermediate machines after substantial operating experience with those machines is gained and companies become confident of their ability to increase the size of equipment and predict the costs involved.

2. Power generation from wind energy is noted for several locations in California. What other areas of the United States are presently being developed with concentrations of wind machines? At those locations, what conditions also exist relative to state public service commission regulations and state tax credits?

No other areas of the United States are presently being developed to anything like the extent of the California windfarm development areas. However, that is partly because California sites were the most favorable during the period of the federal tax incentives for wind energy. California was capable of absorbing, and did absorb, the entire production of the world's wind energy industry for its first four years.

Windfarm development is possible at many other locations in the United States, but the major obstacle which must be overcome is local wholesale power prices.

To some extent, this is a real economic problem. Pacific Gas & Electric Co. has estimated that windfarms can be built using presently available turbines that will produce power for six cents per kWh. Although this is well below the other solar electric technologies, it is still higher than the production costs in most areas of the United States.

In another sense, however, this is also a political problem. The President has recently announced a $5 billion federal initiative to mitigate the effects of acid rain, which is believed largely to result from coal-burning power plants. Yet the costs of acid rain cleanup are not reflected in the cost of power produced by coal-fired generating stations. Similarly, the capital costs of nuclear power stations, which have in some cases resulted in very high levelized power costs (20 cents per kWh and up), are often not considered comparable to wind energy by utilities because wind machines do not produce baseload power.

These issues must be resolved in order for wind energy to make a major contribution to the U.S. utility grid. Failing that, wind energy is likely to be limited in the near term (5-10 years) to a few market niches such as Hawaii where power generation costs are indisputably very high.

One encouraging development in recent months has been consideration of wind energy by one Upper Midwest utility as a possible peak-shaving technology, since high winter loads in that region result from high winds. We are hopeful that this will culminate in commercial development in the region.

Our next panel is Mr. Carel Otte of Unocal Corp. and Mr. William F. Uhl, and I'm going to ask Mr. Walgren to introduce Mr. Uhl. I understand he's from some little town up in Pennsylvania.

Mr. **Walgren**. Well, thank you, Mr. Chairman. I do appreciate the opportunity to welcome to the committee, Bill Uhl, who comes from my hometown. Our hometowns are not that large, and I'm trying to think whether we've ever had a witness from my home town before, before the committee, and I somehow doubt it.

Mr. Uhl is with Pittsburgh Industries, PPG Industries, formerly Pittsburgh Plate Glass but now PPG Industries, and is the residential construction market manager for the glass group of that company. We want to invite everybody to come see the new PPG building in Pittsburgh, which is the only thing akin to a glass palace that I have ever seen, that now dominates the skyline of Pittsburgh and will far into the 21st century. It's a measure of the role that glass has to play in the future of American society and cities in particular, and I particularly appreciate Mr. Uhl's being a resource to the committee because he represents a very practical appreciation of the role that DOE has played in energy conservation, particularly in the area of glass, and so he is a good resource for us.

Thank you, Mr. Chairman. I appreciate the opportunity to welcome him.

Mr. **Fuqua**. Thank you very much.

Dr. Otte, we'll be pleased to hear from you.

STATEMENT OF DR. CAREL OTTE, PRESIDENT, UNOCAL GEOTHERMAL DIVISION, UNOCAL CORP.

Dr. **Otte**. Mr. Chairman, members of the committee, I'm Carel Otte and I'm president of Unocal Geothermal Division, Unocal Corp. Unocal has been engaged in the exploration and production of geothermal resources for almost 25 years. We are considered one of the pioneer developers of geothermal energy and we are the world's leading producer of this resource. I have been in charge of our company's geothermal work from its inception, and over the years have witnessed the buildup and phasedown of the U.S. Government's geothermal budget and program; first under the AEC, subsequently ERDA, and now DOE. Particularly following the second energy crisis in the late 1970's, I saw the buildup of DOE's geothermal energy budget reach a peak in the years of 1979, 1980 and 1981 at an approximate average level of $150 million annually.

The budget has come down rapidly from these levels in subsequent years, and fiscal 1986 is at the spending level of approximately $28 million, and for fiscal 1987 we're discussing a budget of $17 million. Thus, we are talking about funding levels of slightly more than one-tenth of the high mark in the early 1980's. Also, these reductions in DOE's geothermal budget have not come proportionately in all phases of the program, and some parts have suffered more cutbacks than others. One can then rightfully ask whether a meaningful program can be carried out at all at these low levels?

My answer to this question is affirmative. Yes, we can have a meaningful program at these funding levels, but it becomes mandatory that we establish priorities and spend the moneys on those aspects of the program that will be most cost-effective and will do the most good in the shortest timeframe.

Gentlemen, I represent the private sector which is trying to develop an alternative energy resource in a tough, competitive climate of falling energy prices and with the additional prospect of losing certain tax benefits as proposed under Treasury II and Rostenkowski I. And the industry is trying to do this with, as yet, inadequately developed tools and techniques.

With this as a background, you can appreciate that I am concerned about making it this year and next. I am concerned about solutions to technical problems that can reduce my exploration risks and development costs today. I am much less concerned about identification of resources that may be developable in the 21st century. If this industry does not take a firm foothold and establish a sound basis in the next 5—perhaps 10—years, we do not have to worry about the 21st century because this industry will not be around to develop it.

With this premise, let's examine the program numbers.

For fiscal 1987, $3 million is allocated to geopressured resources; $5 million for hot dry rock technology; and $1 million for magma energy extraction research for a total of $9 million. This means that over half of DOE's 1987 budget is for projects that are, at best, of interest in the year 2000, and more likely a generation later. But the hydrothermal research programs that are of great interest to the industry have born a disproportionate burden of the cutbacks since 1979 and are now down to about $6.5 million. In fact, almost all the DOE's program successes that are currently being reported have found an application in hydrothermal resource development to date. But more such successes are needed if geothermal is to compete on the level playing field the President wants us to.

I believe, gentlemen, the thrust of my comments is probably becoming very clear. My recommendations are, one, hold or expand hydrothermal and hard rock penetration research at the levels of 1986.

Two, if cutbacks are needed, and in reference to Gramm-Rudman, phaseout immediately the programs in hot dry rock, geopressured, and magma research. If this drastic a phaseout is unwise or unprecedented, or cannot be done for other reasons, phase the program down with a defined schedule and specific targets over the next 2 years.

I request close coordination between DOE and industry to jointly identify areas of needed research and avoid duplication.

The funding levels should be at a level so that they are adequate to maintain a program at a reasonable pace to maintain momentum and attract the good people. I would call it a critical minimum effort.

Finally, I plead with you, definitely maintain a research program in DOE and do not cancel the support. It has been said by members of Office of Management and Budget that industry should and would take care of these problems. This will not happen. The industry is too immature; we're too fragmented; we're too competitive, as we should be, and we're too diverse so that we cannot work together without the cohesive forces and the leadership that is provided from DOE.

Thank you for allowing me to state my views, and I'll be happy to answer any questions that you may have.

[The prepared statement of Dr. Otte follows:]

STATEMENT OF DR. CAREL OTTE

BEFORE SUBCOMMITTEE ON ENERGY DEVELOPMENT

AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

February 27, 1986

U.S. HOUSE OF REPESENTATIVES

Mr. Chairman, Members of the Committee, I am Carel Otte, and am President of Unocal Geothermal Division, Unocal Corporation. Unocal has been engaged in the exploration and production of geothermal resources for almost 25 years. We are considered one of the pioneer developers of geothermal energy and we are the world's leading producer of this resource. I have been in charge of our company's geothermal work from its inception and over the years have witnessed the build-up and phase down of the U.S. Government's Geothermal Budget; first under the AEC, subsequent ERDA, and now DOE.

Particularly following the second energy crisis in the late seventies, I saw the build-up of DOE's geothermal energy budget reach a peak in the years '79, '80 and '81 at an average of almost 150 million dollars annually.

The budget has come down rapidly from these levels in subsequent years and Fiscal '86 is at a spending level of approximately 28 million and for Fiscal '87 we are discussing a budget of 17 million.

Thus, we are talking about funding levels of slightly more than one-tenth of the high mark in the early eighties. Also, these reductions in DOE's geothermal budget have not come proportionately in all phases of the program, and some parts have suffered more cutbacks than others. One can then rightfully ask whether a meaningful program can be carried out at all at these low levels?

My answer to this question is affirmative. Yes, we can have a meaningful program at these funding levels, but it becomes mandatory that we establish priorities and spend the monies on those aspects of the programs that will be most cost-effective and will do most good in the shortest time frame. Gentlemen, I represent the private sector which is trying to develop an alternative energy resource in a tough, competitive climate of falling energy prices and with the additional prospect of losing certain tax benefits as proposed in Treasury II or Rostenkowski I. And the industry is trying to do this with, as yet, inadequately developed tools and techniques.

With this as a background, you can appreciate that I am concerned about making it this year and next; I am concerned about solutions to technical problems that can reduce my exploration risks and development costs today. I am much less concerned about identification of resources that may be developable in the twenty-first century. If this industry does not take a firm foothold and establish a sound basis in the next five years, we do not have to worry about the twenty-first century, because this industry will not be around to develop it.

With this premise, let's examine the program numbers. For Fiscal '87, $3 million is allocated to Geopressured Resources, $5 million for Hot Dry Rock Technology and $1 million for Magma Energy Extraction Research for a total of $9 million. This means that over half of DOE's '87 budget is for projects that are, at best, of interest in the year 2000, more likely a generation later. But the hydrothermal research programs that are of great interest to the industry have borne a disproportionate burden of the cut-backs since 1979 and are now down to about $6.5 million. In fact, almost all the DOE's program successes that are being reported have found an application in hydrothermal resource development. But more such successes are needed if geothermal is to compete on "the level playing field" the President wants us to.

I believe, gentlemen, the thrust of my comments is probably becoming very clear. My recommendations are:

(1) Hold or expand hydrothermal and hard rock penetration research at the levels of 1986.

(2) If cut-backs are needed, phase-out immediately the programs in Hot Dry Rock, Geopressured and Magma Research. If this drastic a phase-out is unwise or unprecedented, or cannot be done for other reasons, phase the program down with a defined schedule and specific targets over the next two years.

(3) Request close coordination between DOE and industry to jointly identify areas of needed research and avoid duplication.

(4) The funding levels should be at a level so that they are adequate to maintain a program at a reasonable pace to maintain momentum and attract the good people. I would call it a "critical minimum effort".

(5) Finally, definitely maintain a research program in DOE and do not cancel support. It has been said "that industry should and would take care of these problems". This will not happen. The industry is too immature and too diverse that it cannot work together without the cohesive forces and leadership of DOE.

Thank you for allowing me to state my views. I will be happy to answer any questions you may have.

Mr. **Fuqua**. Thank you very much, Dr. Otte.
Mr. Uhl.

STATEMENT OF WILLIAM F. UHL, JR., MARKET MANAGER FOR RESIDENTIAL CONSTRUCTION, PPG INDUSTRIES, INC.

Mr. **Uhl**. I'd like to thank Congressman Walgren for the kind introduction.

Mr. Chairman, I am Market Manager for Residential Construction for the Glass Group of PPG Industries, and am responsible for the marketing of our new low-emissivity coated glass, Sungate.

PPG and others are conducting basic and applied research into highly selective transparent materials and coatings for solar control. In addition to research relating to low-emissivity, high-transmittance products, research is being directed to high-reflectance products and to switchable materials and coatings. Switchable materials and coatings are characterized by their ability to change optical properties under varying imposed conditions.

Switchable systems generally fall into three categories: Photochromics, which are switched by changes in lighting; thermochromics, which are switched by changes in temperature; and electrochromics, which are switched by changes in electrical conditions. PPG has engaged in work relating to each of these subjects with a view toward the development of new and useful consumer and construction products.

Our immediate focus is on passive solar glazing systems, including low-emissivity products, because of the benefits that such products can provide now. My opening remarks are offered in this context.

I am representing PPG in support of continued Department of Energy funding for research in passive solar technology as part of the solar buildings budget line item; more specifically, to continue research in areas that influence advanced glazing materials. The ultimate goal is the development of glazing materials that provide improved thermal performance, and that are cost-justified during a reasonable payback period, while providing occupant comfort and visual aesthetic value.

The basis for PPG's support of funding for research and technology transfer is that first generation advanced glazing products are now in the marketplace and are being accepted by the public as a way to conserve energy without aesthetic compromises. PPG views these first generation products, known as low-emissivity coated glasses, as the beginning of many more to be developed, which involves basic research into even more advanced glazing products. Government, through the Department of Energy, is pursuing projects of this sort currently, and PPG is conducting research relating to advanced products. The significance is that as the public purchases and accepts today's new glazing products over the next few years, the likelihood of acceptance of the advanced technology products in the future will be greater, so the investment in research today for related products will have a greater likelihood of success tomorrow.

I would like to review briefly the background of low-emissivity coatings. The term, low emissivity, refers to the ability of a coating on the glass to reduce conducted heat loss. The lower the emissivity of an object, the higher the reflectance of radiant energy.

During the daytime the sun's energy, visible and short wave infrared, travels through the window into the room and is absorbed. When the energy is reradiated by objects in the room as longer wave infrared rays, it tries to escape to the cooler, outdoor side of the window at night. This is where low-emissivity coatings have their primary advantage, since they are highly reflective to the long-wave heat energy in the room. In essence, coated glass is designed to tell the difference between energy wavelengths.

Low-emissivity glass has benefits in the summer, also. The key to summer performance is by the reduction of solar heat gain.

The research work and the technology transfer of the Department of Energy was instrumental in developing the first commercialized low-emissivity product for glazing, which was applied to a plastic film suspended between two panes of glass, as an insulated glass unit. That work in the mid-1970's and the interest it generated encouraged PPG and others to move forward with the technology. Further developments in coatings chemistry and production equipment by the glass industry and its suppliers have resulted in four major U.S. glass companies now offering windows with low-emissivity coated glass to consumers. The major market is for residential window and door use, since in addition to improved thermal performance, the glass appears clear and transmits 90 percent of the amount of visible light of standard clear insulated glass.

PPG estimated that the market in 1985 consumed 25 million square feet of low-emissivity glass. By 1990, the market will grow to over 300 million square feet, representing approximately 25 million windows in homes.

As described, it should be evident that today's low-emissivity glass is primarily an energy-conserving glazing product. It can be employed in traditional home designs without architectural modifications.

Current low-emissivity glass may be used in passive solar applications, where maximum heat and energy gain is not the foremost consideration, but where insulating value is of primary concern. Today's products reduce solar energy gain somewhat, as well as reducing heat loss. Technology to provide for high solar gain exists and relies primarily on the use of high-transmittance glass substrates. We believe that as more people become aware of low-emissivity glass, the interest in passive solar home design will increase regardless of the fact that high energy costs are not in the headlines anymore.

As we look beyond the present state of the art in passive solar control glazing systems, our ongoing research activities can be expected to provide further improvements in passive products and the introduction of switchable glazing products for uses where precise control of transmittance is desired. Applications research, as well as basic research into the fundamentals of efficient energy use sponsored by the Department of Energy, would be of great value to encourage effective transfer of technology embodied in solar control glazing products into systems of general benefit to consumers. PPG, as well as others interested in advancing passive solar technologies, appreciated the efforts of the House Science and Technology Committee in supporting the proposal of $900,000 for solar buildings technology transfer for the fiscal year 1986. But PPG is concerned that much of the Department of Energy proposed budget reduction—driven by Gramm-Rudman—of nearly $4 million in fiscal year 1987 versus fiscal year 1986 for solar buildings will impact passive solar research. Today we seek your support for a larger portion of the fiscal year 1987 Department of Energy budget for passive solar-related activities.

I would like to add that PPG supports the concept that all new products should have value in the marketplace and should be cost-justified by the final consumer, to warrant investment in research and production facilities. While PPG has stated that low-emissivity glass used in passive solar applications should be considered as solar energy property for inclusion in any energy tax credits that might be renewed, we are convinced that new glazing products yet to be developed should, and in fact will, be of such significant value that incentives such as tax credits will not be necessary to their commercial success.

It is PPG's position that it would be a significant contribution by the Department of Energy to continue advanced research in the building components area of solar buildings, with appropriate contact with, and technology transfer to, interested materials suppliers. We believe that, in the latter stages of product development, that applied research, investment and commercialization are more effectively handled by industry.

Second, and just as important, the ongoing research by DOE in the area of building systems research and development will contribute to the overall knowledge base of how the most effective passive solar buildings may be designed and operated. This envelope evaluation approach seems to be well served as a Government research function, since no single company supplies all the products for an individual residential or non-residential building. DOE results of integrated systems testing will aid manufacturers in developing their particular products that will contribute to the overall energy effectiveness of buildings. These joint efforts should serve to promote the viability of the passive solar energy concept to architects and homeowners.

Mr. Chairman, PPG Industries appreciates the opportunity to testify today before this subcommittee. I will be happy to respond to any questions the subcommittee may have.

[The prepared statement of Mr. Uhl follows:]

TESTIMONY TO THE HOUSE OF REPRESENTATIVES
SCIENCE AND TECHNOLOGY COMMITTEE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

WASHINGTON, D.C.
FEBRUARY 27, 1986

Mr. Chairman, my name is William F. Uhl, Jr., Market Manager for Residential Construction for the Glass Group of PPG Industries. I am responsible for the marketing of our new low-emissivity coated glass, Sungate®. PPG and others are conducting basic and applied research into highly selective transparent materials and coatings for solar control. In addition to research relating to low-emissivity, high-transmittance products, research is being directed to high-reflectance products and to switchable materials and coatings. Switchable materials and coatings are characterized by their ability to change optical properties under varying imposed conditions.

Switchable systems generally fall into three categories: photochromics which are switched by changes in lighting; thermochromics, which are switched by changes in temperature; and electrochromics which are switched by changes in electrical conditions. PPG has engaged in work relating to each of these subjects with a view toward the development of new and useful consumer and construction products.

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I am representing PPG in support of continued Department of Energy funding for research in passive solar technology as part of the solar buildings budget line item; more specifically, to continue research in areas that influence advanced glazing materials. The ultimate goal is the development of glazing materials that provide improved thermal performance, and that are cost-justified during a reasonable payback period, while providing occupant comfort and visual aesthetic value.

The basis for PPG's support of funding for research and technology transfer is that "first generation advanced" glazing products are now in the marketplace and are being accepted by the public as a way to conserve energy without aesthetic compromises. PPG views these "first generation" products, known as low-emissivity coated glasses, as the beginning of many more to be developed, which involves basic research into even more advanced glazing products. Government, through the Department of Energy, is pursuing projects of this sort currently, and PPG is conducting research relating to advanced glazing products, also. The significance is that as the public purchases and accepts today's new glazing products over the next few years, the likelihood of acceptance of the advanced technology products in the future will be greater, so the investment in research today for related products will have a greater likelihood of success tomorrow.

I would like to review briefly the background of low-emissivity coatings. The term "low-emissivity" refers to the ability of a coating on the glass to reduce conducted heat loss. The lower the emissivity of an object, the higher the reflectance of radiant energy.

During the daytime, the sun's energy, visible and short wave infrared, travels through the window into the room and is absorbed. When the energy is re-radiated by objects in the room as longer-wave infrared rays, it tries to escape to the cooler, outdoor side of the window at night. This is where low-emissivity coatings have their primary advantage, since they are highly reflective to the long-wave heat energy in the room.

In essence, low-E coated glass is designed to "tell the difference" between energy wavelengths. In the winter, light and heat from the sun is transmitted, but once that energy has entered a house, these coatings act to keep it inside. And, of course, the coated glass reflects heat generated internally by the furnace and appliances.

Low-emissivity glass has benefits in the summer, also. The key to summer performance is the reduction of solar heat gain. The coating on the glass reduces relative heat gain in the summer (and winter) by 12 percent in an insulated glass unit, so less heat enters the home through the windows.

The research work and the technology transfer of the Department of Energy was instrumental in developing the first commercialized low-emissivity product for glazing which was applied to a plastic film suspended between two panes of glass, as an insulated glass unit. That work, and the interest it generated, encouraged PPG and others to move forward with the technology. Further developments in coatings chemistry and production equipment by the glass industry and its suppliers have resulted in four major U.S. glass companies now offering windows with low-emissivity coated glass to consumers. The major market is for residential window and door use, since in addition to improved thermal performance, the glass appears "clear" and transmits 90% of the amount of visible light of standard clear insulated glass. Other product benefits:

The "drafty feeling" is reduced, since the glass on the inside of the home is warmer.

Room-side condensation is reduced.

Fabric fading is reduced.

PPG estimated that the market in 1985 consumed 25 million square feet of low-emissivity glass. By 1990 the market will grow to over 300 million square feet, representing approximately 25 million windows in homes.

As described, it should be evident that today's low-emissivity glass is primarily an energy-savings glazing product. It can be employed in traditional home designs without architectural modifications.

Current low-emissivity glass may be used in passive solar applications, where maximum heat and energy gain is not the foremost consideration, but where insulating value is of primary concern. Today's products reduce solar energy gain somewhat, as well as reducing heat loss. Technology to provide for high solar gain exists and relies primarily on the use of high-transmittance glass substrates. We believe that as more people become aware of low-emissivity glass, the interest in passive solar home design will increase, regardless of the fact that high energy costs are not in the headlines anymore.

As we look beyond the present state of the art in passive solar control glazing systems, our ongoing research activities can be expected to provide further improvements in passive products and the introduction of switchable glazing products for uses where precise control of transmittance is desired. Applications research, as well as basic research into the fundamentals of efficient energy use sponsored by the Department of Energy, would be of great value to encourage effective transfer of technology embodied in solar control glazing products into systems of general benefit to consumers. PPG, as well as others interested in advancing passive solar technologies, appreciated the efforts of the House Science and Technology Committee in supporting the proposal of $900,000 for solar buildings technology transfer for the fiscal year 1986 budget. But PPG is concerned that much of the Department of Energy proposed budget reduction -- driven by the Gramm-Rudman law -- of nearly $4 million in FY'87 versus FY'86 for solar buildings will impact passive solar research. Today we seek your support for a larger portion of the FY'87 Department of Energy budget for passive solar-related activities than in FY '86.

I would like to add that PPG supports the concept that all new products should have value in the marketplace and should be cost-justified by the final consumer, to warrant investment in research and production facilities. While PPG has stated that low-emissivity glass used in passive solar applications should be considered as "solar energy property" for inclusion in any energy tax credits that might be renewed, we are convinced that new glazing products yet to be developed should, and in fact will, be of such significant value that incentives such as tax credits will not be necessary to their commercial success.

It is PPG's position that it would be a significant contribution by the Department of Energy to continue advanced research in the building components area of solar buildings, with appropriate contact with, and technology transfer to, interested materials suppliers. We believe that, in the latter stages of product development, that applied research, investment and commercialization are more effectively handled by industry.

Just as important, the ongoing research by DOE in the area of building systems research and development will contribute to the overall knowledge base of how the most effective passive solar buildings may be designed and operated. This "envelope" evaluation approach seems to be well served as a government research function, since no single company supplies all the products for an individual residential or non-residential building. DOE results of integrated systems testing will aid manufacturers in developing their particular products that will contribute to the overall energy effectiveness of buildings. These joint efforts should serve to promote the viability of the passive solar energy concept to architects and homeowners.

Mr. Chairman, PPG Industries appreciates the opportunity to testify today before this subcommittee. I will be happy to respond to any questions the subcommittee may have.

(END)

Mr. Fuqua. Thank you very much, Mr. Uhl.

You noted in your testimony that four of the major glass companies now offer windows with the low-emissivity coated glass. Is that an indication that the Department of Energy has done its job, and that private enterprise will take over and that we don't really need this continued research into these areas?

Mr. Uhl. The point that I was trying to make was that the first—what I call the first generation—products of this glass have been accepted in the marketplace, and I think your indication of the four companies supplying these products is a testimony to the fact that they believe that these products are good products for the homeowner.

The point is that we believe that we're just beginning to develop future products that—I'm calling them second generation products—where we can use the contributions of the Department of Energy work in doing some of the basic and advanced research, and also work with the envelope building systems' analytical information that will serve both the viability of the passive solar concept and, hopefully, give industry some direction on the type of products that we should be working with in the glazing area that will help to optimize the thermal efficiency of these buildings.

Mr. Fuqua. Well, what about in the cooperative R&D venture programs that have been discussed today? We don't know what they're going to be, but does that have some hope?

Mr. Uhl. Mr. Chairman, we are presently evaluating—PPG is presently evaluating, on a project-by-project basis, and also with a direct contact with some of the scientists active on some of these programs with the Department of Energy—whether or not this idea will have merit.

Also, PPG is a member of the Passive Solar Industries Council, which is a group of suppliers of components for passive solar buildings. And this organization is also in the process of evaluating the feasibility of this approach.

Mr. Fuqua. Let me as you and Dr. Otte both, if you think that the Department of Energy does a good job in trying to transfer the results of their basic research to industry?

Dr. Otte. It depends on the programs that we're talking about.

Mr. Fuqua. Sure, and it would vary among programs, I'm sure.

Dr. Otte. The thrust of my testimony today was basically more on applied research, and these are the immediate things that we need. We are engaged in drilling wells. When we develop geothermal energy, we drill very similar to the petroleum industry; these are entirely different resources, but still, we drill wells.

The bulk of our capital investment for the resource development part is associated with the drilling. The above-ground surface systems are fairly well understood and competitive and they don't lend themselves for a great deal of technological advancement. But there's an incredible amount of advancement in the drillingarea because we're drilling in geological terrains where nobody has ever drilled before; maybe where you were sinking shafts and tunnels in the mining industry, but you don't drill wells. So therefore, there's a lot to be learned.

And in those areas, this is where DOE has been active. It has been a modest program because they've been trying to leapfrog, sort of, into the 21st century. What we would like to see now is a more increased emphasis on the immediate area so that we improve our technology for the drilling of wells. Those are the wells that are also needed; once we have discovered a field, you need to drill 30 or 40 wells over the life of a system, and there's a lot of substantial capital investment associated with it.

Our costs are probably three to four times as high as drilling an oil well to equivalent depth.

Now, we take pride, in the industry, that we currently have a cooperative effort going. It started this past year; it is based on discussions we have had with then Assistant Secretary Joe Trible when he was in charge of the Department of Conservation and Renewable Energy Resources in the early 1980's. We have a geothermal drilling organization; we're considering changing the name to Geothermal Technology Organization. It has been funded, both by DOE and by the private sector; we have carefully selected certain programs in order to develop instrumentation and techniques to apply in the field. We want to expand that effort.

Now, the way we see this happening—and we hope both OMB and DOE and the Committee on Science and Technology can be cooperative on this—we see sort of a functional marriage coming along, and not necessarily an undivided contribution, like you contribute $1 million and we contribute $1 million. So let me give you an example of what I see.

Instrument development that comes out of one of the weapons laboratories like Sandia. This particular instrument may need field testing. Well, it is unnecessary for DOE to drill a will in order to have a hole in the ground in which to test. This is where industry—for instance, Unocal, and we have steps for it—where we can make one of our wells available in the proper geologic setting and framework in order to test the necessary instruments. Then, both the scientists from the private sector as well as the Department of Energy are available to collect the data and assess it and see how it is and how we proceed from there.

When it comes to the improvement of drilling bit technology, and there have been incredible improvements made—not enough yet to satisfy us, because we drill in a very hot hard rock environment—but when it comes to application of a new drill bit, we can run it into one of our holes that we are drilling for commercial purposes.

So this is where I see a functional marriage. We contribute in kind with facilities, and they contribute, perhaps, with the research facilities of one of the national laboratories.

I also see programs—like, for instance, on a more immediate level—the service industries in the petroleum industry, the ones that manufacture drill bits or subsurface orientation tools. They have a long history of doing R&D work and commercial development. It sometimes would be unwise to start from scratch and develop new techniques or equipment in the lab, and it is better to just fund the research of an existing industrial facility because the people are there with all the prior experience, can hit the ground running, and we can make more progress.

So we want to be flexible. I think there are good communications between DOE and the geothermal division and the industry, and we would like to see that continued and reinforced. That is the general thrust that we would like to see the program take in a general environment where we have to cut back. We are realists; there are great demands on the money, so we would like to see it more focused.

Thank you.

Mr. **Uhl**. If I may, I'd like to add my comments.

As mentioned in the text, some of us in the industry attempted to have a specific amount of money in the 1986 budget for solar buildings for tech transfer. We were not successful with that, although the individuals with whom we're familiar apparently have made their best efforts to see that some of this did occur. Obviously, we would prefer that the tech transfer activity continue and be increased.

A couple of specific examples that were used—one, in particular, was a very successful seminar last August in Las Vegas where the past activities and accomplishments and future direction was charted by members of DOE with participants in industry for a group of academics and manufacturers in this whole advanced glazing area.

Also, I would like to mention that at present there sits a facility that I believe cost $1.2 million to develop, which is called MOWITT, which is a side-by-side window glazing facility whose budget is being questioned. We believe that the relatively small operating costs for developing timely information that could be used for effective tech transfer would be well served by moving forward with this specific project.

Our contacts in the industry, with members of DOE, have been extremely worthwhile this last year. They have expressed a direct interest in what we see as a direction from the top administrators of DOE to become more involved with industry and make technology transfer more a part of their activities. So we wholly support this technology transfer activity.

Mr. **Fuqua**. Mr. Walgren.

Mr. **Walgren**. Thank you, Mr. Chairman.

Mr. Uhl, what can you tell us about the efforts being made in other countries in this area? You mentioned two areas of research in your testimony, one in coatings and glazings and the other in building systems as a whole. Can you describe any of the efforts that are being made abroad, and then compare them to what we're able to do?

Mr. **Uhl**. Specifically in the area of advanced glazings, which I have mentioned as switchable films—which would be a product type of development—we at PPG feel that we have a good understanding of the level of technology in these areas from Japan especially, and Europe to a degree, that is published in patent literature and the public record.

In the area of spending on energy conservation, some recent data that we have acquired indicates that the United States ranks behind Japan and at least three Western European countries in the overall expenditures in the study and analysis of thermal use in buildings. So we feel that especially there, there is a need for a building systems approach that would benefit the country.

Mr. **Walgren**. Both of you gentlemen are practically involved with this gray area where Government is able to do something of help to the development of a particular technology, and yet, clearly, there are in that continuum areas that you have real appreciation that the private sector is there to develop. Mr. Uhl, you used in your testimony at some point, the idea that in the latter stages of product development, that applied research investment and commercialization are clearly in the private sector's domain. Yet, you've been in a position to see an effort made by Government in the earlier stages, and now you certainly want to encourage Government to continue to be involved in those earlier stages.

It's hard for Members of Congress to operate in that gray area because the political arguments are always either black or white; either you should do that, or you shouldn't do that. What I'm reaching for is to ask you for some way that you could speak to the value of Government in those initial stages in your experience, both of you, and any suggestions as to how we define that point where we should be moving, sort of totally with the private sector.

Mr. Uhl, you indicate in the earlier part of your testimony that the Government is pursuing projects of a certain sort, and PPG is conducting research relating to advanced glazing, also. Now, to many Members of Congress, that means you've got two entities doing the same thing, and they feel that obviously the Government at that point should probably get out. Can you expand on that a little bit so that we might have a better appreciation of what the Government does constructively, and where you've seen it make a real contribution?

Mr. Uhl. I think in answer, Mr. Congressman, to the first part of your question, which seems to be, "Where does Government stop and industry take over?"In my interpretation of this with the example that was used, in the first low-emissivity product, and also our philosophy at research, would be that when an agency of the Government or the scientist has proved the feasibility of the concept on a bench scale, in other words, they've shown that the idea works. At that point it is up to the interested companies in industry to take the ball and run with it, to develop a repeatable process, to get the adequate cost projection to do the market research in determining whether the product can be made with a cost benefit that will sell in the marketplace. Then, make the investment in the technology.

The latter expenditures in most cases, I believe, are usually much greater than the basic research expenditures by the Government; in fact, I believe that the case that was presented here was a good example of this actually occurring.

In terms of the apparent conflict of the type of programs that we're involved with versus the Government, and any redundancy, I think that is also a part of the research philosophy of PPG per se. Being the world's largest glass manufacturer, we have committed a significant amount of our internally-generated funds to developing new products, and also products that are proprietary products and ones that we believe we can hold a significant competitive position with.

So we would be doing this activity to a degree that we feel is appropriate with or without Government assistance. So I don't believe that we have an inherent conflict here, other than the fact that I think that our timeframe on development may be a little bit shorter because of realities of business conditions than could be viewed by either Department of Energy, which could possibly take a longer timeframe for development of the products.

Mr. **Walgren**. If I could ask, where does the "cost-shared" research concept come into this? We're sort of talking about an area proper for Government and an area where industry should have clearly full responsibility for. How do you see cost-shared research playing in this area?

Mr. **Uhl**. Well, I think the most obvious example is where there is very basic research, and there are maybe other members of industry in the same basic area that would have much to gain for shared research. For example, we are funding a project involving one of the space shuttles where we're putting up some money to look at formulation of glass under zero gravity conditions. And this is being shared by various companies worldwide. I think it's a pretty obvious example of an area where the sharing situation——

Mr. **Walgren**. Has there been any cost-sharing with the Government in this area? Whether that's the word of art that would describe that kind of program, I don't know. We tend to be using matching funds these days because it gives it away for the private sector to drive the direction, because their money is the one that pulls the program. Yet, it gets more basic research done, and we feel that generally our society is basic research poor and the more we can add to that area, the better we feel that things are going to go.

Mr. **Uhl**. Well, speaking for our company, I do not believe we have actively pursued that avenue. But as I indicated earlier, we are definitely interested in pursuing this opportunity on a project-by-project and case-by-case basis if it's appropriate.

Dr. **Otte**. We are currently doing that, Mr. Walgren. We have actually two projects underway; they were very carefully selected because it was the initial start, and both the Government as well as the private sector want it to be successful, so they were very carefully selected projects with specific objectives, and there's a great deal of industry input in it. There is sort of an advisory committee that is serving with it, and actually industry is matching funds with the Government in this particular situation.

To broaden the scope along the lines that the chairman was asking me earlier, I believe that we should allow for a greater degree of flexibility of the mixture of the contributions, like I was describing where the private sector can either make personnel available or can make facilities available for actual field testing. Facilities would be very expensive; for instance, to drill a bore hole in geothermal costs about $1.5 million, and an opportunity to run equipment in that is an incredible opportunity because the hole is somewhat threatened and the condition could be threatened by it. Yet, at the same time, it is terribly important to have the proper geological and geothermal conditions. So in order to even find and locate a field test facility, so to speak, may be exceedingly expensive.

So each party can kind of blend and contribute what they can best do, and I think that should be left to the managers of the program or the managers of the DOE rather than let the programs be very circumscribed, either by the budget process or the appropriation process.

I'm hopeful that this program will expand. I will say this somewhat with a caveat because—as you are well aware, of course—what is happening to the prices of crude oil and natural gas will follow very shortly, and what you have probably witnessed and read in the papers, that all the energy companies are drastically reducing their exploration programs by about: third or 40 percent. Daily I read that some of our competitors are again cutting back 30 or 40 percent of a $1 billion program.

Well, our lifeblood is exploration for new resources. The first thing that even goes before that is research; immediately, research programs that are somewhat long-range are deferred because when you're struggling for survival, that's what goes out. So I am somewhat concerned, and I'll say this with a caveat. I don't know what the reception in industry will be, but let's say 2 years ago, when we were working together, trying to solicit support for these cost-shared programs, the reception was very good.

In your question to the other panelists here earlier, Mr. Walgren, you know, we read this; there's a research program in DOE and likewise, PPG has a research program. Well, I don't know how it specifically works in some of the other technologies, but I would say this, that a program in writing—particularly in the synopsis form, in a budget book like we're examining—a program, when boiled down, looks like it is the same, like both are working on the same effort. In reality, they're really working, maybe, in the same area but on different products. It's sort of like working on semiconductors; there are semiconductors and semiconductors, and it is highly competitive. Yet, it may look like it is an overlap and at the same time it is very competitive and very different.

So I think, again, these are judgments that probably should be made by the individual Government and department managers. There is not that much overlap; in fact, if the private sector feels that it's overlap, it moves out and takes its money somewhere else because it is not interested in duplication, either.

Mr. **Walgren** [acting chairman]. Well, the chairman asked me to express his apologies that he had to go to meet a commitment, and to thank you both for being a resource to our hearing process. So thank you very much.

[Additional questions and answers follow:]

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UNOCAL

Carel Otte
President

April 8, 1986

The Honorable Don Fuqua, Chairman
Committee on Science & Technology
U.S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

Thank you for your complimentary words about my testimony before the Subcommittee on Energy Development and Applications on February 27, 1986.

Following are some additional comments on the questions raised by members of the Subcommittee. (See attached sheet for the two questions.) I regret that these thoughts are so late, but I had given up on making the deadline because of pressing other business: These are difficult times in the Energy Sector.

Answer to Question 1. The research carried out under the geoscience program in DOE's office of Energy Research addressed more basic earth science problems associated with geothermal energy developments. Studies to obtain a better understanding of geothermal systems, their occurrence, their age, and their geological setting are being undertaken by the U.S. Geological Survey and DOE's Geoscience Program. The results will be needed for the industry really to take off, but we need to guard against overlapping programs between agencies of different departments and avoid duplication in programs. When moneys are short, some of the programs could be stretched out.

DOE's geothermal program is more on the engineering aspects of geothermal development; how to do things better and more economically. The program is more applied.

Answer to Question 2: I addressed this question in my testimony. Superficially, it is my opinion that geopressured Hot Dry Rock and the Magma Resources will not be developed until 20 to 30 years from now. The only resource that is technically and economically viable at this time, and for the near future, is the hydrothermal. However, there are elements in the programs that are useful to hydrothermal developments, particularly the development of certain high temperature instruments and tools for downhole application. These will be useful in hydrothermal and deep oil and gas exploration and development.

Mr. Chairman, I hope my comments are of use to you and the Committee members. Thank you for allowing me to testify.

Sincerely yours,

Unocal Corporation

Original Signed By
Carel Otte
Carel Otte
President
Geothermal Division

CO/jh
attach.

cc: **Ms. Lynn Draper**

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Conservation and Renewable Energy

February 27, 1986

Followup Questions

Dr. Carel Otte

1. To what extent is the Geoscience program in DOE's Office of Energy Research beneficial to the geothermal program? Or should the relationship be reversed?

2. The Department of Energy is currently pursuing four types of geothermal resources: hydrothermal, geopressured, hot dry rock, and magma. What is your estimate of the promise of each of these resources?

PPG Industries, Inc. One PPG Place Pittsburgh, Pennsylvania 15272 (412) 434-2290

William F. Uhl, Jr.
Market Manager
Residential Construction
Glass Group

RECEIVED
APR - 3 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

March 25, 1986

Congressman Don Fuqua
Chairman
Committee on Science and Technology
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

[Attn: Mr. William T. Harvey, Jr.]

Dear Mr. Chairman:

With regard to the follow-up questions you indicated in your letter of February 27, PPG Industries' answers are attached. Thank you again for the opportunity to testify before the Subcommittee, and for your continued support of passive solar and energy conservation research and development.

William F. Uhl, Jr.

William F. Uhl, Jr.

WFU:vb

PPG ANSWERS TO FOLLOW-UP QUESTIONS:

1) Research in passive solar programs by PPG involves focus on specific glazing products. PPG is not now funding research on passive solar buildings (structures) or other components of passive solar building design. The elimination of DOE projects on passive solar components may well result in a longer time for new products to be developed, since industry tends to have a shorter time frame focus with basic research, compared to that of the government. PPG is unable to comment on the amount of product research being conducted by other companies.

2) Based on our knowledge of the programs related to buildings in the solar energy portion versus the conservation portion, it does not appear that there are significant technical impediments to combining these areas. The obvious advantages are the elimination of possible overlap in the systems analysis area, especially. Administration may also be simplified. One potential disadvantage would be the elimination of assimilation of programs that are specific to passive solar technologies. In this regard, PPG urges legislation or report language earmarking funds for specific programs in the passive solar area.

3) For PPG to be involved in a "cooperative R&D venture" with DOE, PPG would need the assurance that it would receive the benefits of its own funded portion, which in most cases would be a proprietary position with a specific technology.

4) To our knowledge, PPG does not have any current cost-sharing projects with the Department of Energy. However, government requests for proposals for joint project work are being evaluated by our research staffs.

5) PPG's interest in research in advanced glazing materials centers around switchable films. DOE can make contributions in the specific areas of thermochromics by developing new suitable candidate films, and in electrochromics by refining the composition of multi-layer candidate films and determining how these "user-active" systems can operate. We are not nearly at the stage of "diminishing returns", since these technologies have not been proven, even at the lab or bench scale stage. There is still much basic research to be conducted. It would be especially useful for DOE to assess and monitor Japanese and European developements, and include the findings in the Department's technology transfer activities.

6) As noted in our February 27 testimony to the Energy Subcommittee, PPG is funding our own research in advanced glazings. The actual amount is proprietary for competitive reasons, but ongoing expenditures are based upon a longer-term payoff. PPG cannot estimate total glass industry research expenditures in advanced glazings. The ongoing support of the Energy Development and Applications Subcommittee is requested so that breakthroughs in products for energy conservation may become a reality.

[Whereupon, at 12:45 p.m., the hearing was adjourned.]
[Additional statements for the record follow:]

Los Alamos
Los Alamos National Laboratory
of the University of California
Los Alamos, New Mexico 87545

March 7, 1986

The Honorable Don Fuqua
Subcommittee on Energy Development
and Applications
Committee on Science and
Technology
U. S. House of Representatives
Washington, D.C. 20515

Dear Mr. Fuqua:

We are pleased to respond to your request for information regarding the Hot Dry Rock geothermal energy program at the Los Alamos National Laboratory. Enclosed is a brief description of the program for inclusion in the record of the March 5, 1986 hearing on Solar and Renewable Energy by the House Science and Technology Committee's Subcommittee on Energy Development and Applications. I appreciate the opportunity to submit a statement recognizing that time constraints do not permit a personal appearance at the hearing.

If you should need additional information, please contact my office at 505-667-5101 or the office of the Deputy Associate Director for Alternative Energy Sources, M. E. Berger, at 505-667-3973.

Sincerely,

S. S. Hecker
Director

SSH:sw

STATEMENT
FOR THE
HOT DRY ROCK GEOTHERMAL ENERGY PROGRAM

of

Michael E. Berger
Deputy Associate Director
Alternative Energy Sources
Los Alamos National Laboratory

to

United States House of Representatives
Committee on Science and Technology
Subcommittee on Energy Development and Applications

March 5, 1986

The Hot Dry Rock Geothermal Energy Program is funded by the U.S. Department of Energy and, under an International Energy Agency Agreement, by the government of Japan.

Thank you, Mr. Chairman, for the opportunity to report on the progress of the Hot Dry Rock Geothermal Energy Program. I am pleased to report to the Committee that all key program milestones have been met on schedule and within budget.

The thermal energy in hot rock beneath the earth's surface is one of our nation's largest, most accessible, and most secure supplies of inexhaustible energy. The primary objective of the Hot Dry Rock Program is to develop a solid technology base for this energy option, so that private industry can confidently evaluate its reliability and economics. The significance of this research has also been recognized internationally as the government of Japan, through an International Energy Agency Agreement with the Department of Energy, continues to support this program.

As you may recall, the method developed for recovering heat from the earth's crust is to drill two wells and connect them through a series of cracks or fractures produced by pressurizing one of them. Water pumped down one well is heated as it circulates through the fractures, and is brought to the surface through the other wells under sufficient pressure to keep it from boiling. The useful heat is removed in heat exchangers, and the water is returned to recirculate and recover more heat. Because this is a closed circulation loop, the system is environmentally benign.

Several years ago Los Alamos completed the world's first hot dry rock system at Fenton Hill in the mountains of northern New Mexico. We operated it for more than a year. It brought heat to the surface at a temperature of about 280°F, and at a rate such that it could have heated several hundred houses for many years. Using this energy, we did generate 60 kw of electricity - enough to power the site. We have since undertaken development of a larger, deeper and hotter system.

As we reported to this Committee last year, we have drilled two wells at Fenton Hill to depths of about 14,000 feet, where the rock temperature is above 600 degrees F, and have attempted to connect them by pressurizing one of them. In our largest fracturing experiment, we pumped almost six million gallons of water out into the rock at a pressure of about 7000 pounds per square inch when a pipe broke. This permitted the water in the well and the fracture system to return to the surface and shoot out at high pressure, and temperatures far above boiling. We had a man-made geyser that erupted for over a week. It was convincing proof that we had created a large fracture system. However, the fractures did not connect to the other well, and the violent eruption seriously damaged the casing, the pressure tubing, and the special hardware used to seal the opening between the casing and tubing. Our first major job last year was to repair the damage.

Simply determining the location and nature of the damage in a very hot well at a depth of about two miles is an extremely difficult job, and repairing it involves some technically risky operations. However, with the help of the best industrial experts we could find, we did repair the well and subsequently pressure-tested it to about 5000 pounds per square inch. It was one of the most difficult well-repair jobs ever attempted.

During a fracturing operation the formation and extension of the fractures are accompanied by small sounds that can be detected by very sensitive instruments. It is very important for us to know the location of the fractures we produce. In order to do so, we have pioneered the mapping of fractures by carefully locating where the sounds originate. This micro-seismic mapping technique has already been used in several other research programs and in a number of industrial applications.

Our maps of the fracture locations showed that fractures are distributed throughout a volume of rock about 3000 feet long, 2600 feet high, and 500 feet thick--about four billion cubic feet of fractured rock. Unexpectedly, this great zone of broken rock passed to the north of the other well, and did not intersect. This was quite different from the fracturing behavior we observed in developing the earlier system. This discovery caused us to change plans for completing the connection. We redrilled an existing well--turning it away from its old trajectory--and drilled it into the fractured reservoir. Drilling out of an existing hole in rock as hard as granite is difficult. However, we were able to drill out the side along a new trajectory directed toward the fracture system. At this point we reached the maximum safe working depth of the drill rig, and it was dismissed. In spite of the difficulties encountered, this high-risk operation--like the well repair in the other hole--was completed on schedule.

Our plans for the next steps in the drilling operation were carefully reviewed by industrial experts with broad geothermal experience, and a larger drilling rig was assembled at Fenton Hill. Drilling operations proceeded as planned. However, directional drilling of deep holes in hot, hard rock is difficult, and major problems may occur. Fortunately, we had very few, and in fact, we increased our drilling rates by more than 50% over previous drilling experience in granite, resulting in a 50% decrease in drilling time. Drilling operations were completed in ninety days at a cost of about $2M.

The next step after drilling into the man-made reservoir was to conduct short-term stimulation experiments to develop connections between the two wells. Again, we were successful. Connections were made at 11,700 feet to about 12,000 feet, additional connections from 12,000 feet to 12,300 feet and several more connections at even greater depths. In July 1985, an 84-hour flow test was successfully completed in the rock where the temperature was about 500°F.

Our scientists and engineers were able to isolate and test very specific zones along the well bore because of the successful engineering development of an "open-hole" packer. This project was undertaken jointly by engineers from Los Alamos and Baker Production Technology in less than nine months of intense design, testing, and manufacturing. Not only was our program able to use this new technology, but the geothermal industry now has a packer system that can operate successfully in temperatures in excess of 450°F and at high pressures in hot, open wells.

Reservoir testing, essential research, and planning have continued through February of this year as we are preparing for another key program milestone this spring. The initial closed-loop flow test of 14 to 30 days duration is scheduled for April, 1986. This test is critical for establishing preliminary technical information on the system. For example, key elements such as reservoir volume, flow distribution, impedance, and water-loss rates will be analyzed. With this information the design and construction can begin on the surface system for the final long-term flow test. This test is critical to completing a solid technology base for private industry and will begin immediately after the surface system is complete, hopefully in FY 1987.

In summary, 1985 and early 1986 saw critical technical successes. Plans were developed, carefully reviewed by private industry, and implemented on schedule and within budget. Drilling rates were improved by 50%; a new packer system was designed, tested and successfully employed; and the micro-seismic research system validated. A series of connections was made between the man-made reservoir and the wells. All of these activities were accomplished without a single accident, despite severe winter conditions and around-the-clock operations.

However, perhaps the most significant accomplishment was the validation of a new approach to hot dry rock system development. No longer required are two steeply inclined wells. We believe we have proven that a single well can be drilled or an existing, perhaps abandoned well can be used to create a man-made reservoir. By using the micro-seismic mapping technology, the reservoir can be located. The next step is to drill into the fractured region, thus completing the system. This new approach should greatly reduce both the risks and costs of commerical hot dry rock systems.

This year, total funding for the Hot Dry Rock Program is $10.0M of which the Department of Energy provided $7.5M and the government of Japan, $2.5M. These funds allowed for essential field work and critical research. However, FY 1986 funding constraints forced a 25% reduction in the Laboratory's geoscience research team and have not been sufficient to finish final surface system design, nor order major long-lead components required to complete the surface system. These steps must be undertaken in FY 1987 before we can begin the long-term flow test and complete the last major building block for a viable technology base.

The technical accomplishments to date have been significant, but there are key experiments and tests that must be accomplished before this technology can be successfully tranferred to the private sector. Long-term test data on the man-made reservoir is required to prove the technology. In order to complete this closed-loop test a surface system must be constructed at a cost of about $1.5M for equipment. Without adequate funding, both the surface system and long-term test must be deferred for another year. This postponement could seriously jeopardize the opportunity for Japan to continue the IEA agreement. In order to achieve success, $8.0M from the Department of Energy are required in FY 1987.

Much of the technology developed for the Hot Dry Rock Program has already been adopted by industry, including improved drilling and well-completion equipment, high-temperature instruments, and acoustic fracture-mapping methods. However, even more importantly, the U.S. program has brought worldwide attention to the fact that hot, dry rock exists at temperatures and accessible drilling depths almost everywhere, and that the technology to develop hot dry rock energy systems by hydraulic fracturing is approaching the point at which it can be applied commercially. Interest in such systems has been encouraged by several preliminary economic studies already published, and we anticipate it to be increased by a more vigorous economic analysis now being made independently by the Electric Power Research Institute.

Strong interest in proceeding with the construction of commercial-scale hot dry rock systems has already been expressed within the United States and in other countries. The possibility of undertaking such a project has been discussed in recent months with representatives of the California Energy Commission, the State of Utah, and the New York Energy Research and Development Authority. Japan also believes that hot dry rock systems can be important both there and throughout the Pacific Basin. A research program exists in Great Britain and there are smaller, complementary programs in several other countries. A recent report in the technical press states that three hot dry rock projects are being undertaken in the Soviet Union. The magnitude and potential contribution of the hot dry rock energy resource is now being recognized domestically and internationally.

The U.S. Hot Dry Rock Program is the broadest, most ambitious, and most advanced in the world. We sincerely appreciate the support this committee has given the technology in the past, and hope that this support can be continued so that hot, dry rock can soon be used to improve our energy security.

REQUESTED OUTSIDE WRITTEN TESTIMONY

DR. JOHN E. CUMMINGS, DEPARTMENT DIRECTOR, ELECTRIC POWER RESEARCH INSTITUTE
PALO ALTO, CALIFORNIA 94303

SOLAR AND RENEWABLE R&D
DEPARTMENT OF ENERGY
FY87 BUDGET

COMMITTEE ON SCIENCE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES, WASHINGTON, D. C.

INTRODUCTION

The purpose of this testimony is to offer a perspective on Department of Energy supported activities essential to the transfer of viable solar technologies for use by electric utilities for bulk electric power options.

Over the past decade, electric utilities through support of the Electric Power Research Institute (EPRI) and individually, as well, have committed significant resources to determine which solar applications have the potential as bulk electric power plants on their electrical systems. With the encouragement of the Department of Energy, utilities have become very much involved in photovoltaics, wind and solar central receiver systems development with the view of identifying cost efficient and modular plant additions in the decade of the 1990s.

We are now at a critical juncture in programs, in all of the above areas, where I feel continued Department of Energy presence and support is essential to assure effective technical transfer and ultimate commercial readiness.

Some perspectives derived from EPRI research management experience and from recent interviews with several involved utilities are contained in the following testimony.

Photovoltaics

High Concentration:

Recent achievements in cell development research and in efforts to bring this technology to the manufacturing stage, coupled with successful central station photovoltaic (PV) projects in California, have increased our confidence that photovoltaics could be a viable generating option for utilities in the southwestern United States in the next decade.

Whether the economics and technology will evolve sufficiently to permit expanded geographic application to other areas of the country may depend on the success of intensive worldwide research into amorphous thin-film semiconductors -- the next generation of PV materials beyond today's silicon crystals. Characterized as at a stage of development analogous to that of conventional solar cells 15 years ago, amorphous materials may require another decade of relentless, fundamental research before they can rival today's crystalline cells.

High-concentration (500 X) PV systems that focus the sun's rays into intense beams on small-area ($\sim$1-cm^2) cells and track the sun for maximum exposure are emerging as the frontrunner for meeting utility requirements for near-term economic bulk power generation. EPRI has sponsored concentrating-silicon-cell PV technology research which began 10 years ago with scientists at Stanford University.

The team recorded 22.8% efficiency in quarter-scale (15-mm^2) laboratory cells at 500 X geometric concentration. Cells operating at only 100 X concentration have recorded efficiencies just over 25%.

The next big step will be to determine whether the concentrator cell can be manufactured in high volume and with consistent quality and efficiency. EPRI and several utility cosponsors expect to spend some $10 million over the next three years on research, engineering, and equipment to demonstrate cell manufacturability.

Over the past years, Sandia National Laboratories in Albuquerque, as the lead laboratory for concentrating photovoltaics, has developed an impressive program related to high concentration photovoltaic device and module testing and PV systems understanding. This program is in jeopardy under the DOE FY1987 Congressional Budget Request. I feel it is essential that these activities and capabilities be maintained to ensure the orderly evolution of technology transfer to the market place.

Thin-Films:

A very different kind of PV cell than that made from single-crystal semiconductors has rapidly garnered much of the world's hope and R&D attention as the leading PV technology that promises to make solar cells widely applicable and affordable. These cells are thin-films of amorphous silicon or silicon germanium (a-Si or a-SiGe) or poly-crystalline materials, such as copper indium diselenide or cadmium telluride. Each is sensitive to a specific part of the light spectrum; used in combination they can, in principle, convert more of the light to electricity than can conventional silicon crystals. Moreover, the materials can be vapor-deposited on foreign substrates (glass, for example) in layers 0.5 um thick to yield complete modules in fewer steps than are required for conventional cells.

The excitement about thin-films stems from the potential to deposit multiple layers of semiconductor materials or alloys at high rates of production. Each layer in a multijunction cell absorbs only part of the light, letting other parts of the spectrum pass through to be absorbed by the layers underneath. Because they absorb more light, including the diffuse fraction that concentrator cells cannot capture, tandem thin-film solar cells have the potential to be economic in regions not known for their sunny climes (i.e., beyond the Southwest).

I feel the promise of thin-film photovoltaics warrants a high priority of support. In addition, the effort to achieve acceptable efficiencies and costs will involve, for several years, a fundamental device physics research effort. Success then is very much dependent upon dedication and continuity of program over the next seven to ten years.

Field Demonstration:

As significant advancements are achieved in photovoltaic conversion efficiencies, cost reduction and systems development, systems must be demonstrated before electric utilities can incorporate them into their electrical generation mix with any confidence in reliability. I believe it is important for the Department of Energy to participate in such efforts to underwrite some part of the risk in bringing photovoltaic systems into commercialization.

During the course of its own extensive research in photovoltaic power technology, the Pacific Gas and Electric Company (PGandE) has perceived the need for an additional effort to bridge the gap from current R&D activities and systems tests to readiness for broad utility application. Discussions with other organizations in the PV industry have confirmed this special need in photovoltaics development which derives from the wide variety of PV cell and balance of system (BOS) technologies, their differing levels of maturity, their divergent applications in industry, and the fundamental influence on system design of differing site insolation characteristics.

To develop PV technology to the necessary point of readiness, PGandE, supported by Bechtel National, Inc., proposes this cooperative R&D project, Photovoltaics for Utility Scale Applications (PVUSA). Project PVUSA will provide a test bed for the application and further development in a utility setting of current and ongoing R&D activities by DOE and others. A highly credible bridge will be created for focusing the transfer of R&D technology to the utilities for commerical application.

This R&D project will deploy, test, and evaluate multiple emerging PV technologies and innovative BOS approaches in utility-scalable power generation segments. Two test sites have been selected which provide the differing characteristics of direct and diffuse insolation. All emerging PV technologies will be considered for deployment, and studies of innovative design concepts will identify potential system improvements. Technology transfer to industry will begin in 1987, continue through the lifetime of the project, and be facilitated through the onsite participation of interested utilities and component manufacturers. By project completion in 1995, it is anticipated that 10 MWp of PV power generation segments will be in operation, those PV technologies ready for commercial power plant demonstration will have been identified, and an extensive "utility-friendly" data base will have been established and disseminated.

Wind:

An item of major concern to the electric utility industry is that DOE is currently seeking a deferral of $10,240,000 which was appropriated last year for the MOD 5B multi-megawatt wind turbine. The electric utility industry has supported the development of a large, multi-megawatt wind turbine since the MOD 5 program was initiated in 1980. Nearly $70 million has been appropriated for the MOD 5B program and work is very nearly completed.

The Boeing Company is under contract with NASA and DOE to design, fabricate and test the 3.2 megawatt wind turbine. The MOD 5B wind turbine design is completed and procurement and fabrication of all major components have been accomplished. Electrical and mechanical assembly has been proceeding on the rotor and nacelle and shipment of these major components to Hawaii was scheduled for April 1986. Site preparation and foundation work in Hawaii have been completed and tower construction is currently in progress at the site. First rotation of the wind turbine has been scheduled for September 1986 and it was anticipated that Hawaiian Electric Industries would accept delivery of the machine at the end of the testing period which is scheduled for March 1987. The proposed deferral of MOD 5B appropriations at this crucial time will mean cancellation of the project or, at least, substantial delay.

The electric utility industry has a continuing interest in wind energy systems as an economical means to add energy to the power grid. Utility industry participation in wind energy projects is particularly important because only then can the electric utility industry acquire the information needed to insure that wind turbine electric generation is properly integrated into the utility grid. Completion of the MOD 5B machine is imperative if we are to complete the government programs in this area and to provide the utility industry with the experience by which to accurately judge the usefulness of large wind energy machines.

Congress and the Administration should continue and complete this important demonstration project. The multi-megawatt wind turbine is the centerpiece of nearly a decade of federal, and now private industry, effort. To terminate the program at this time when we are so close to completion is not advisable.

Reviewing the progress of commercialization for small and intermediate (up to ~ 500 kW) wind turbines, over 13,000 machines, have been installed over the past few years, mostly in California. To insure the best use of R&D support for advanced wind turbines, I strongly urge the DOE, through its Solar Energy Research Institute wind program, to significantly augment its efforts to catalog performance and operating and maintenance experience from the wind parks already in place. This experience should provide the basis for research in wind turbine advancements.

Solar-Thermal Conversion:

Encouraged by the Department of Energy, three electric utilities, Arizona Public Service, Pacific Gas and Electric and Southern California Edison have submitted proposals to undertake systems studies for the Central Receiver Solar-Thermal (Power Tower) development. Activities under these studies would include:

- System trade studies for full-size plants
- Description of scaled test facilities if needed, and
- Assessing techniques by which utilities can finance new, first of a kind power plants.

EPRI has agreed to participate in the efforts in a technical review capacity.

I would encourage support of these studies and if sufficient progress is demonstrated, provision for continued support in FY1987 and beyond.

Alabama Power Company
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291
Telephone 205 250-1000

Alabama Power
the southern electric system

March 5, 1986

The Honorable Don Fuqua
Chairman
Subcommittee on Energy
 Development and Applications
B-374 Rayburn House Office Bldg.
Washington, D.C.   20515

Dear Chairman Fuqua:

Enclosed please find the written statement of Mr. Herbert M. Boyd, Manager, Forecast and Strategic Planning, representing Alabama Power Company's position on research expenditures required between now and the year 2000. I respectfully request that this be submitted for the record for the hearings you held on February 27, 1986, entitled "Department of Energy's FY 1987 Authorization for Conservation and Renewable Energy."

Sincerely,

Phillip R. Wiedmeyer

Phillip R. Wiedmeyer
Manager, Federal
Legislative/Agency Affairs

Enclosure

PRW:prs

STATEMENT OF

HERBERT M. BOYD

MANAGER-FORECAST & STRATEGIC PLANNING

ALABAMA POWER COMPANY

Submitted for the Record

to:

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

Hearing Entitled:

"Department of Energy's FY 1987

Authorization for Conservation and Renewable Energy"

February 27, 1986

I appreciate you giving us the opportunity to present a utility view on research expenditures required between now and the year 2000. The Southern Company and Alabama Power Company, in particular, are concerned about the prospects of having new technology available to meet its generation requirements in the years 1995 - 2000.

We have had a number of national leaders such as John F. Kennedy who fostered the idea of the new frontier and President Reagan, who is currently fostering the idea of opening that frontier. Each of these presidents appears to have had a vision of what they believe the future holds for this industry. As I understand both of their approaches, energy will be required in great abundance to make these two visions possible. The economy and their visions will only move forward in response to energy availability.

We in the utility industry know that the social aspects of our society have created a concern for the environment in which we operate and live. This concern has created untold amounts of regulation which place pressure upon the energy supplying community. The utility industry and Alabama Power Company, in particular, are concerned that if sufficient research is not performed to develop new technologies then the old technologies will have to be utilized to meet the increasing energy needs of our society. This being the case, the adaptation of existing technology to meet the increasing needs might not be sufficient and the cost to society might be prohibitive.

The Southern Company system is continuing to plan for generation to meet its customer requirements. As a point of reference the embedded cost of capacity in 1973 was $117 per KW. The difference in these costs represent the change in cost due to technology as well as inflation and environmental requirements. The significant fact is that we are projecting that the cost of installed generation by the year 1991 will be $1708 per KW. It is clear from these numbers that every effort should be made to identify any technology which could impact these costs in a positive way.

We can state that the current technology being utilized to produce electric energy is not obsolete; it is, however, mature and the dollars required to increase the efficiency of that technology in response to required environment changes and societal needs will be tremendous. Therefore, with the pressure of regulation and competition it is time that we as a nation attempt to sustain a program that has pushed the development of new technology which are not currently available or ready for application. We need to take a sustained approach to solving the technological problems associated with emerging technology and commit to a long range program to identify energy producing technologies.

We can state that there is no "clear" winner in the set of new technology currently being investigated. Therefore, we as a nation can take three possible approaches to doing basic research on new energy producing technologies. We can make no expenditures on basic research and in the period 1995 - 2000, when most utilities will have to make large additions to meet this country's energy requirements, we will be forced to install technology that was developed in the 1960's & 1970's. This clearly would not be an efficient alternative. We can make some expenditures in basic R & D and maintain our current level of technology. This will allow us to install 1980 technology in the year 2000. Still not an acceptable alternative but one that would at least be better than making no expenditures. The best alternative, however, is to make expenditures at least at a level which would maintain the critical mass of research. This is the level of expenditure required to move technology forward so that when the period 1995 - 2000 does arrive we can meet the full requirements of our society.

Photovoltaics, the direct conversion of sunlight to electricity, is one of the promising options to help meet the electrical demand of the country in the 1990's and beyond. The government has an important role to play in the development of the photovoltaic technology because energy is of national and world importance. Any new technology like photovoltaics takes time to develop. As a high risk technology, it demands a continual commitment on the part of both the government and private sector to ensure steady progress toward a favorable outcome. As a high technology with associated high risks, photovoltaics also demands a long term commitment to nurture its development.

The past and present government program in photovoltaics has resulted in technological progress. Increasing the risks of technology development has also been shared between the public and private sectors through the use of federal/industry partnerships. However, the government's support has tended to fluctuate wildly, simply following the rapid changes in the price of oil. This results in disrupting the steady progress in developing the research base and forces researchers and private sector planners to question the priorities of the Government's interests. In the meantime, our competitors' program from across the Pacific - Japan, under the sponsorship of the Ministry of International Trade and Development (MITI) - at the very least consists of a steadily increasing government support base with a strong interrelationship with their private companies. In turning to photovoltaics for power generation, America had a clear leadership position in technology development through the 1950's to the early 1980's. However, 1985 may prove to be a turning point, and 1986 should show Japan as a leader in a strong position to develop photovoltaic products for an export market. Surely, the U. S. Government is capable of better planning for a more effective use of public resources to meet the challenges of the 1990's in supplying the country's energy needs through a mix of energy resources.

The photovoltaic industry is still very small compared with other high technology industries. Revenues for 1985 are estimated to be only $150 million. Profitability is virtually non-existent. World economic forces have slowed the deployment of the technology. Further technical progress must be made in reducing the cost of photovoltaics to accelerate its growth. Industry alone cannot afford to support the research necessary to make this technical progress in a timely fashion, since its revenue base is so small. Continuing government help is mandatory to develop the scientific foundations upon which a large scale industry can grow.

You are wrestling with the problem of when do I make technology expenditures. I would like to give you just one R & D guideline, "When the existing technology requires tremendous expenditures in order to increase the output for the same dollar input and no technology is present that has the potential for producing large outputs for small input expenditures then large R & D dollars are required to develop new technology." This is where we are today.

The overall DOE photovoltaic research program has the right goals. Increasing the efficiency and increasing the utilization of the available light spectrum is a must if photovoltaics are to ever be competitive with current generation resources. It does, however, appear that a strategy assessment of the areas of priority should be made so that the R & D on photovoltaics could be focused in a direction to solve problems necessary to speed the commercialization and economics of the photovoltaic technology. As other technologies have proven, universities are an excellent resource for basic research. The universities in this country have made a large contribution to basic research and they will continue to do so in the future, however, universities can not be expected to make the contributions which will be required for commercialization. They can, however, help us in the area of performance and stability and they can generate new processes for fabricating devices which result from their basic research. This leaves a large area within the general field of R & D that must be carried out by those people which are attempting to commercialize and improve the economics of the technolcgy. These two efforts must go hand in hand if we are to successfully complete our goals in the photovoltaic industry. The budget which DOE has described does not address the attending delays that will result from the budget reductions which have been identified. Therefore, it appears that no one is assessing the cost of the delays and the attendant risk that will result from those delays. This risk is that we will not have a photovoltaic technology ready when it is needed unless we move forward with an ambitious R & D program today.

The electric industry is willing to make application of proven technology to meet its customer requirements. Being regulated, utilities have traditionally been unable to spend the large amount of capital required to do basic research.

In order to increase flexibility, we are reviewing a wide range of potential sources of additional generating capability and load control techniques other than the traditional central station power plants. This efforts includes:

A. Solar Technology. We have promoted in several ways the development of new technology aimed at making solar resources more attractive as a source of electricity for the future at competitive prices. Our joint venture with Chronar Corporation for the development of a factory in Alabama to produce solar cells is one such project. In addition we are installing a 100

KW amorphous silicon generating plant which will be integrated into the electric grid at Varnons, Alabama. This plant is designed to aid in research concerning the use of photovoltaics.

B. Cogeneration Efforts. We have established a task force within the system companies to explore with customers those applications of cogeneration which make sense to the customer and which also are complimentary to our plans for meeting loads in the future. While the Southern electric system companies have no current avoided capacity costs as a result of the installation of cogeneration, we recognize that such resources may be valuable to meet our load requirements in the future.

C. Other Non-Traditional Resources. Our research and development organization, in addition to participating on various projects with EPRI, is continuously engaged in looking at development of other non-traditional resources for production of electricity such as the advance coal liquefaction project which the southern electric system has supported at Wilsonville, Alabama, and fuel cells powered by methane gas from coal beds.

We also expect to be able to control our loads more effectively in the future. Toward that end, we are exploring numerous means of promoting load management and conservation. One of our major current efforts is the promotion of the wise use of electricity for residential purposes through our Good Cents Homes Program. This program establishes voluntary standards to assure an energy efficient home design. Through application of these standards, our customers are encouraged to make wise use of electricity and at the same time reduce the overall cost of home heating and cooling.

In pursuing a strategy of flexibility, we have also been exploring the revitalization of generating plants in lieu of retirement of those plants. Normally, a steam electric generating plant is expected to remain in service for 30 to 40 years. If the life of these plants can be extended, an added degree of flexibility can be achieved to permit quicker response to upward changes in electric usage patterns. The advantages of revitalizing old units include making use of existing plant sites and providing resources in the short run at lower costs. The disadvantages include placing the reliability of the electric system at risk by reliance on units which are more than 40 years old; utilizing units with less efficient heat rates to serve loads; and using temporary, stop-gap measures while the cost of new generating plants continue to rise.

While we are pursuing all of these alternatives in order to maintain flexibility, it is apparent to us that in the long run, these resources will not completely replace the need for larger, central station power plants if we are to meet the demand for electricity in the late 1990's. In order to preserve the opportunity for developing these needed resources, impediments which currently exist to the development of such plants must be eased.

In closing, I would like to stress that it is society's responsibility to insure that adequate and efficient technologies are available in the future to meet its requirements. R & D dollars are required today if we want this to occur by the 1995 -

2000 timeframe. We, the electric utility industry, are looking to you to provide continued direction and incentive for the research that needs to be done. The best statement that you could make to the industry is that our society will continue to support the development of new energy producing technology.

Thank you very much.

INNOVATIVE FINANCING: A SURVEY OF PROJECTS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY

Prepared by
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EXECUTIVE SUMMARY

This report describes projects supported by the U.S. Department of Energy that feature innovative approaches to the financing of energy efficiency improvements.

Encouraging energy efficiency has been a major concern of DOE since the Department's inception. Especially in the past two years, DOE has taken a number of steps to encourage, familiarize people with, and demonstrate realistic approaches to using a variety of innovative financing techniques to fund energy efficiency improvements.

These DOE initiatives include: (1) funding demonstrations in a number of building sectors; (2) sponsoring analyses and studies of opportunities for the use of innovative financing; (3) providing grants to States that support a range of services relating to financing; and (4) working to eliminate legal and regulatory roadblocks to using innovative financing for improvements to government buildings.

This report will describe why and how DOE has become involved in encouraging the use of innovative financing for energy efficiency improvements.

INNOVATIVE FINANCING: A SURVEY OF PROJECTS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY

This report describes the many recent efforts undertaken by the Department of Energy to encourage building owners to consider using innovative approaches to financing energy efficiency improvements when traditional sources of funding are unavailable. DOE first became interested in innovative financing in 1981, but most of its efforts are more recent, with many being initiated since 1983. The majority of the projects are now underway (a few have been completed), and they will be generating results for a number of years into the future.

The Department has always considered the encouragement of energy efficiency as one of its important concerns. In several areas (low-income residences, nonprofit schools and hospitals) DOE provides grants to help finance energy efficiency improvements to buildings. DOE also provides grants for energy related technical analyses of local government buildings and for the support of State offices which in turn sponsor a wide variety of energy efficiency initiatives. In other areas such as residential, commercial, and industrial buildings, DOE sponsors a range of research and development projects designed to improve energy efficiency in those sectors. DOE also has the lead in promoting energy efficiency improvements in buildings owned by the Federal Government.

In addition to the direct assistance provided for improvements to hundreds of thousands of low-income residences and thousands of institutional buildings, DOE's efforts to demonstrate the value of energy efficiency improvements (both through its grant programs and its research) have stimulated many building owners to make new or additional improvements on their own, when they were financially able to do so. However, many building owners have been unable or unwilling to finance large capital improvements even when they were aware of the virtues of doing so.

DOE's direct assistance is limited in both amount and extent of coverage. Therefore, in order to supplement its programs, DOE has been exploring the possibilities for the utilization of alternative and innovative financing strategies by building owners who are otherwise unable to pay for needed improvements. More private sector involvement, particularly in the financing of improvements, is crucial if significant additional progress is to be made in the foreseeable future.

In the last several years a number of innovative financing approaches have been offered by equipment vendors and energy service providers. Some of the innovative approaches being offered are adaptations of familiar equipment acquisition methods such as leases or installment purchases, while others are relatively new, such as shared savings and tax-exempt municipal leasing. (A list of definitions of major financing methods as used in this report is included as Attachment A.)

There has been a tendency to give these new financing techniques generic names like "shared savings" or "third-party financing," but in fact not all of the approaches involve either shared savings or third party investors. To avoid confusion, in this report the term innovative financing will be used to cover all the non-traditional financing mechanisms used to acquire energy efficient capital equipment.

In general, the approaches discussed in this report share one characteristic--the building owner does not have to make an initial capital investment in the energy efficiency improvements. Payments are usually made over a period of years..perhaps 5 to 10 years..often based on savings generated or on some guaranteed amount which is advantageous to the user (for instance, there may be a commitment that utility bills will not rise, or will actually be lower than in the past).

While the concept seems relatively simple (equipment which is designed to save energy is installed in a building, and the installer and the building owner subsequently share in or otherwise benefit from the savings achieved) in actual practice there are many difficulties. Great skill is often required on the part of the equipment provider to both: (1) realistically estimate the savings to be obtained; and (2) maintain or oversee the equipment to ensure that projected results are realized. In many innovative financing arrangements if savings are not achieved, the vendor does not get paid. On the other hand, building owners who do not understand their own buildings' energy use characteristics may agree to an arrangement which shortchanges them on equipment or service, or both.

For innovative financing to work to the best advantage of both the energy service provider and the building owner, each must be fully aware of the commitment being made. For a variety of reasons (including naivete on the part of some building owners, and opportunism and/or inexperience on the part of some vendors), there have been a few well publicized bad experiences in the formative years of innovative financing. Vendors occasionally disappeared without a trace, leaving building owners (and sometimes third party investors) to contend with equipment which often did not operate as promised. A few vendors offered deals which the Internal Revenue Service later said grossly overstated the allowable tax shelter opportunities. Such cases were not the norm; many reputable vendors have long offered legitimate options and programs. But the few bad experiences (combined with the inherent complexity and unfamiliarity of the innovative approaches) have caused many building owners to shy away from innovative financing.

There also have been practical problems encountered by many building owners, particularly in the institutional sector. Among other things, there are competitive bidding requirements and limitations on multi-year contracts which have tended to preclude the use of innovative financing approaches for government buildings. (A number of States, and the Federal Government, are in the process of adapting laws and regulations to permit these approaches to be used.) Even where such restrictions are not a problem there has been a great reluctance on the part of many building owners to try something new, which in the case of innovative financing requires skillful analysis and negotiation on the part of the building owner to achieve maximum benefits.

On the other hand, there also has been some hesitation on the part of vendors to offer innovative financing for certain types of buildings which may appear to present special problems (multifamily housing for low-income tenants, for instance) or which may not seem to offer a lucrative enough opportunity (often small buildings, particularly those in remote locations).

Some building sectors (the Federal Government's huge stock of buildings is a prime example) seemed left out for a combination of reasons, including legal and regulatory uncertainty, perhaps combined with inertia and unwillingness to adapt to innovative approaches. Beyond all of this, there are some building owners who are simply unaware of the availability of innovative financing, especially since the experience with these approaches to encourage energy efficiency is so recent.

As an agency with the responsibility to foster energy efficiency improvements (and with an interest in encouraging the private sector to get more involved in financing those improvements), DOE has taken several roles in this undertaking. Among those roles are: making building owners more comfortable with the concept of innovative financing; making vendors more familiar with opportunities in sectors they have avoided; demonstrating to both building owners and vendors how such approaches can work in carefully structured situations; eliminating impediments and encouraging the use of innovative financing by States and the Federal Government; and, in general, showing that the concept can benefit potential users and service providers in the public and the private sectors. DOE has also emphasized the value and need for expert energy management by building owners of all types, because without that, energy efficiency improvements, however financed, are not likely to achieve and continue to yield the expected long-term results.

While a good energy manager is always an asset, one of the advantages of using many types of innovative financing is that a reputable vendor or energy service provider is going to take every precaution to ensure that installed equipment works as promised and that projected savings are achieved.

A carefully developed innovative financing agreement will benefit both the building owner (who obtains improvements installed at no initial cost and usually also receives low/no cost maintenance over the life of the agreement) and the vendor (who can make a fair return on investment by skillfully assessing the building's needs, installing appropriate improvements, and assuring that those improvements achieve the projected savings).

But these agreements can be extremely tricky, especially for complex installations, and virtually all of their provisions are negotiable. In addition to being made aware of the general concept and its variations, building owners must be aware of how to protect their interests when negotiating such agreements. One of DOE's major efforts to encourage innovative financing has been to sponsor demonstration projects and the development of model documents to show (for various types of buildings) how to best structure such agreements so that both the building owner and the service provider get satisfactory results. Among DOE's efforts (more fully described in the attachments) are demonstrations in commercial, industrial and multifamily buildings, in municipal buildings, in primary and secondary school and college buildings, and in low-income multifamily buildings.

Most of these efforts have been sponsored by the component offices in DOE's Office of State and Local Assistance Programs, which work directly, or through the States, with the major types of building owners and managers needing guidance in this area (such as nonprofit institutions, multifamily housing and governments). DOE has also developed a number of reports analyzing the use of innovative financing in hospitals, and has supported numerous State initiatives to encourage innovative financing at the local level. (Because the various DOE efforts are somewhat different depending upon the needs of the originating offices and their constituent groups, brief analyses of the programs of each major DOE sponsor are included with the descriptions of those programs' individual efforts which appear later in this report.)

Since many of DOE's efforts are ongoing, it will be several years before all of the results are evident. Even as they are progressing, however, these efforts have produced information which is useful. Among the lessons learned by these efforts so far are that: (1) planning and implementing a successful innovative financing arrangement is a time-consuming job for the building owner; (2) it is crucial to know the future plans for buildings, since possible future closings or use changes can significantly affect the likelihood of obtaining innovative financing (or seriously complicate an agreement later, requiring renegotiations, etc.); (3) government buildings (at all levels from Federal to small towns and school districts) are frequently difficult to fit into an innovative financing plan because of complicated, time consuming procurement procedures and frequent changes in management and administration; and (4) not all buildings lend themselves to innovative financing techniques, which work best for relatively low-payback energy efficiency improvements (2 to 3 years would usually be the maximum).

While innovative financing is not the answer to every building owner's need for energy efficiency improvements, it is a viable option for many.

The following program explanations and individual project descriptions give a more detailed view of DOE's various initiatives to encourage and participate in innovative financing for energy conservation improvements. The programs are arranged, as nearly as possible, based on the dates they became involved with innovative financing, starting with the earliest. Where State projects are described, they are arranged alphabetically by State.

BUILDINGS AND COMMUNITY SYSTEMS PROGRAMS

In 1981, the Office of Buildings and Community Systems (formerly the Office of Building Energy Research and Development) in the Office of Conservation and Renewable Energy funded one of the earliest Federal efforts to study innovative financing mechanisms. Through promotion of the results of the study, the office sought to increase the pace of investment in energy efficiency improvements in the absence of Federal financial assistance by spotlighting the availability and feasibility of these attractive financing approaches.

The Office of Buildings and Community Systems has subsequently funded a number of other projects to encourage innovative financing. These projects are described below.

INNOVATIVE FINANCING FOR ENERGY EFFICIENCY IMPROVEMENTS

The Department undertook this study in an effort to attract private sector capital to assist building owners faced with the problems of inefficient energy usage in buildings and lack of capital to finance the necessary improvements. The objectives of this three-part study were to develop and demonstrate the attractiveness of third party financing mechanisms; attract private sector capital to fund energy efficiency investments; draw attention to the feasibility of third party financing; and provide a working model for engineering firms, energy service companies, leasing firms, and others to duplicate.

The Phase I report identified and analyzed the legal, financial, institutional, and behavioral factors to be considered in evaluating the feasibility of six financing options: leasing, bank financing, utility assisted financing, tax-exempt financing, financing by an energy service company, and joint venture financing. In Phase II, the contractor developed model contract documents needed to implement selected financing mechanisms for improvements in the three building sectors. The Phase III report summarized results of the field tests of three different financing mechanisms: energy service company (multifamily building); utility assisted financing (commercial building); and lease financing (industrial building).

This study made a significant contribution to the acceptance and expanded use of innovative financing mechanisms by public and private sector building owners.

INSTITUTIONAL SOLUTIONS TO CONSUMER DECISIONMAKING

This project includes a comprehensive case study review of companies which have marketed products on the basis of energy savings performance; an evaluation of any innovative energy conservation delivery systems that were used, to determine which might be suitable for residences; an analysis of possible application of these to DOE programs; the design of a model residential energy conservation delivery system and description of how it would interface with related existing DOE programs, e.g., Home Energy Rating Systems, Appliance Standards, etc.; and a workshop for experts who would be vital to implementation of the model.

WORKSHOP ON ALTERNATIVE FINANCING STRATEGIES FOR ENERGY CONSERVATION

This workshop presented descriptions of six proposed alternative financing demonstration projects (St. Louis County, Missouri; San Diego County, California; Austin, Texas; Chicago, Illinois; Pittsburgh, Pennsylvania; and San Francisco, California) to public energy managers, and described how the final demonstration sites were selected. (These demonstration projects are being separately sponsored by DOE and are more fully described in the ICP section of this report.) The agenda covered: (1) financing options: what is available, how they work, what is an energy service company; (2) project selection: what are appropriate projects, how to select projects, who puts the project together; and (3) implementation: writing the request for proposals, how to select a service company, how to monitor performance, and the results of previous projects.

FEDERAL ENERGY MANAGEMENT PROGRAM

DOE's Federal Energy Management Program (FEMP) first began discussing innovative financing with other Federal agencies in 1982. Declining appropriations for building improvements over the past several years have prompted Federal agencies to look for ways to make their facilities more energy efficient with no initial capital expenditure.

The Federal agencies decided on two activities to explore the use of innovative financing for improvements in Federal buildings: analysis of possible approaches; and implementation of a pilot project. DOE's Federal Energy Management Program undertook the analysis, and the Department of Defense took the lead in the pilot project. Further progress is now dependent upon legislative changes to permit Federal agencies to enter into long-term innovative financing agreements.

SHARED SAVINGS (FOR FEDERAL AGENCIES)

A study and implementation methodology has been initiated to investigate three possible options for the elimination of impediments to Federal government and government contractor utilization of shared savings contracting to achieve energy savings in government operations and facilities. The options being addressed are: (1) Direct energy services contracting by Federal entities; (2) Establishment of an independent financing organization (revolving fund concept); and (3) Energy services contracting at government-owned, contractor-operated facilities.

CLEARINGHOUSE ON ENERGY FINANCING PARTNERSHIPS

In support of DOE's mission to identify, evaluate, report on and promote activities to conserve energy in the Federal government and among State and local governments (including schools and hospitals), a clearinghouse has been established as a mechanism for technology transfer to assist in the dissemination of information on energy-related alternative financing including shared savings transactions. Among the activities being carried out are: (1) Identifying and acquiring literature pertaining to alternative financing techniques; developing a cataloging system and a keyword list for retrieval; preparing annotation for each citation; identifying individuals, agencies and organizations involved in relevant contracting; (2) Monitoring contract planning, implementation, and evaluation efforts of shared savings transactions by Federal agencies and similar efforts within State and local government sectors, including public and nonprofit schools and hospitals; (3) Preparing and disseminating information on the progress of projects within the public and private sectors and responding to inquiries received on all alternative financing approaches; and (4) Preparing a bibliographic listing of all acquired literature, an events calendar, a resource listing, typical bibliographies, location listings. project summaries showing progress, innovations and/or problems; and preparing a glossary of contract terminology.

INSTITUTIONAL CONSERVATION PROGRAMS

The Institutional Conservation Programs (ICP) provide grants (cost shared on a 50/50 basis in most cases) for technical audits of buildings owned by local governments and public and private nonprofit schools and hospitals, and for energy conservation improvements in buildings owned by schools and hospitals. The ICP grants have provided assistance for energy efficiency improvements in over 40,000 buildings during 7 funding cycles, but many thousands of eligible buildings remain unassisted.

Consequently, ICP took an early interest in innovative financing techniques. The first ICP initiative began in 1982 with a proposal to perform a study/demonstration for institutional buildings similar to the one (described in the BCS section of this report) conducted by the Office of Building Energy Research and Development (now the Office of Buildings and Community Systems). This project is now underway, after DOE obtained the participation and co-sponsorship of the Energy Task Force Management Corporation. The emphasis of this project is to show municipal and other local governments (and, by extension, other institutional building owners) how to successfully negotiate innovative financing arrangements. Because ICP grants cannot be made for energy efficiency improvements in local government buildings, there was particular concern that this sizeable building sector be encouraged to seek financing from innovative sources.

Subsequently ICP has funded a number of other efforts to demonstrate the viability of innovative financing approaches both in general and for particular types of institutional buildings. These efforts include several studies of financing approaches appropriate to hospitals, and a demonstration including several colleges which are members of the United Negro College Fund. In addition, ICP and several States are working on a variety of initiatives to encourage institutions which have applied for, but not received, ICP grants, to seek alternative, innovative sources of funding for energy efficiency improvements.

These efforts have been designed to conform to the varying needs, sophistication, size, and resources of the target groups. But they have generally been planned to: (1) familiarize institutional building owners with various appropriate financing options; and (2) show these owners how to understand, plan for, evaluate, negotiate, and manage innovative financing arrangements. In addition, these projects will familiarize equipment and service providers with the unique problems and needs of institutional building owners.

These projects have been designed to respond to the needs of the institutional sector and also in response to the concern expressed to ICP managers in the States and in the DOE field offices and headquarters. A great many comments on innovative financing have been received by ICP (among other things, as responses to the program's 1985 rulemaking), from a wide range of energy users, engineers, service providers, and program administrators. The concept is quite new and different from traditional purchasing procedures. And the occasional bad experience (particularly with unscrupulous or undercapitalized vendors) reported in the trade press and elsewhere made many building managers and others uncomfortable with trying innovative financing. By educating building owners about such financing, ICP's aim is to ensure that everyone gets a realistic, fair contractual agreement.

ENERGY MANAGEMENT PROGRAMS AT UNITED NEGRO COLLEGE FUND MEMBER COLLEGES

This project will assist low resource institutions in obtaining alternative funding sources to undertake major, capital intensive, retrofit projects which would lower their operating cost and reduce energy consumption, utilizing a series of innovative financing arrangements.

The project is significant in meeting two national objectives: (1) supporting minority institutions of higher education; and (2) encouraging the more efficient use of our energy resources. To date, the low-resource institutions have been unable to undertake energy efficiency investments. This effort would dramatically change their knowledge of what to do and how to do it; and would identify the sources of, and means of obtaining, financing for their energy conservation projects.

More specifically, the proposer will carry out the following: review the energy consumption patterns of all colleges and universities who are members of the UNCF; provide feedback and guidance to each institution on improving its energy efficiency; develop detailed energy efficiency management plans for four institutions selected to be demonstration sites; carry out a technical evaluation of each site; gather/compile site specific energy data; perform analyses of the data, and design four site-specific Energy Management Plans; develop prequalification criteria for identifying energy service providers; and monitor performance after agreements are in place.

BLUE CROSS/BLUE SHIELD MONOGRAPHS

This project involves the development and distribution of three (3) monographs on topics related to energy conservation financing in hospitals. The topics are: (1) Evolving hospital payment methods and their impact on energy conservation (Monograph I will be entitled, "An Executive Briefing, The Conservation Advantage'); (2) Investment opportunities in the hospital energy conservation market (Monograph II will address bridging the communication gap between hospital decision makers and energy service companies); and (3) Strategies for implementing community-based hospital energy conservation financing programs.

INNOVATIVE ENERGY FINANCING FOR THE '80's CONFERENCE HELD IN LIVINGSTON, MONTANA

This conference was held on October 5 through 7, 1983, and brought together 28 speakers from across the country to explain various aspects of innovative financing. The meeting was hosted by the Montana Department of Natural Resources and Conservation. The conference provided one of the first opportunities for such a wide range of participants from federal, State and local governments and from the private sector to discuss and examine innovative financing techniques and related legislative and regulatory issues (including tax considerations).

ENERGY SHARED SAVINGS ARRANGEMENTS: AN ANALYSIS OF THE FINANCIAL AND CONTRACTUAL IMPLICATIONS FOR HOSPITALS

This project is designed to determine the extent to which hospitals are using energy "shared savings" financing for energy capital projects, analyze hospital cash flows under various shared savings plans and various health care payment systems, and develop recommendations to stimulate the use of private shared savings financing for hospital energy conservation.

POSITIVE CASH FLOW FINANCING IN THE INSTITUTIONAL SECTOR

This project involves analyzing the particular financing needs of three areas of public sector buildings--public schools, colleges and universities, and local governments, describing a variety of financing approaches appropriate to those sectors, and developing guidelines and model plans for the use of alternative financing for energy conservation capital projects, to enable the owners of such public sector buildings to benefit immediately from the improvements (i.e., experience a positive cash flow from the beginning) without investing in the improvements. The goal is to identify self-financing projects, with payment for improvements based on the savings generated by the improvements. The project includes the development of criteria for assessing each approach, the identification of possible barriers to using the approaches, and suggested ways of overcoming those barriers.

FINANCING ENERGY CONSERVATION IN MUNICIPAL AND NONPROFIT INSTITUTIONAL BUILDINGS

Three cities have been selected to sponsor alternative financing approaches for conservation improvements in specific municipally owned buildings which are deemed to be most appropriate for alternative financing, most representative of typical local government needs, geographically diverse, etc. Assistance is being provided to each selected city in preparing solicitations for vendors, evaluating responses from vendors, overseeing management of the project, and evaluating the results. A variety of reports are included as part of the project, to share the experiences with other interested local governments and institutions.

LOCAL GOVERNMENT ENERGY MANAGEMENT AND PLANNING

This project involves the development of guidebooks, local government data analyses and workshops targeted at local government energy conservation, using energy budgets as a resource. Cash-flow financing, alternative financing, and shared savings information are covered.

INNOVATIVE FINANCING DEMONSTRATION PROGRAM FOR INSTITUTIONAL CONSERVATION PROGRAMS - FLORIDA

The State (which has large education districts) is assembling collections of public kindergarten through twelfth grade school and community college energy conservation projects for packaging to private investors through joint purchasing, performance contracting, shared-savings or energy service company options. Sample contracts and requests for proposals, and several case study experiences are included in this project.

ALTERNATIVE FINANCING OF SMALL SCALE ENERGY PROJECTS FOR LOCAL GOVERNMENTS - MINNESOTA

This project involves analyzing technical audits for local government and public care buildings, and then soliciting institutions to participate in five or six demonstrations of methods to achieve energy conservation with private funding. The State provides direct technical assistance to each demonstration site and concentrates on identification of legal, financial, and institutional barriers.

ALTERNATIVE FINANCING AND ENERGY CONSERVATION PROGRAMS DEMONSTRATION PROJECT - NEW YORK

Using unfunded applications for ICP grants from private kindergarten through twelfth grade schools and nominations from associations of religious and secular schools, the State acts as a marketing representative to familiarize institutions with alternate financing opportunities and provide technical assistance in the development of Requests for Qualifications, other solicitation documents, and contracts. Associations may also act as general contractors between several institutions and the private investor. Educational materials for both associations and institutions are under development and a series of seminars are planned.

WEATHERIZATION ASSISTANCE PROGRAM

The Weatherization Assistance Program (WAP) has been concerned for some time about the low number of rental dwelling units, particularly in multifamily buildings which have been weatherized under the program. Only about 10 percent of the total dwelling units assisted nationally have been rental dwelling units. By and large, the rental units in which low-income families live are multifamily structures. The reasons most commonly given for the low percentage of multifamily units being weatherized are: (1) the local agencies (which do the actual weatherization work) believe single family homes should receive priority because of the small amount of money available; and (2) landlords are reluctant to participate because of the perceived difficulties of weatherizing these units (requests for audits, determining actual savings, renters' agreements, etc.).

WAP has recently reoriented its program direction and policy emphasis to encourage an increase in the number of multifamily units that are weatherized under the program. However, even if WAP is successful in these efforts, not all eligible buildings can be weatherized with WAP grants. It is evident that there will never be sufficient grant funding to finance needed energy efficiency components in all eligible multifamily units in this country. Therefore, in order to increase the impact of WAP on this building sector and to explore the climate for more public/private partnerships, WAP has undertaken several innovative financing initiatives. These are designed to: demonstrate the effectiveness of selected innovative financing mechanisms anticipated to have the most success in the WAP world; identify the role private financing might play in expanding the coverage of WAP; and more rapidly effect energy efficiency improvements in the low-income multifamily sector.

These innovative financing projects may eliminate some barriers to weatherizing multifamily dwellings as well, through designing projects that put fewer (if any) demands on Federal, State, or local government resources to accomplish the weatherization of large numbers of units. Pilot projects are trying three approaches: shared savings, bank participation, and energy service company/business development.

In the shared savings model, the landlord contracts directly with a shared savings/energy services company to have the weatherization work completed. The State agency provides technical assistance during each aspect of project development. Under the bank participation model, a local agency arranges most aspects of the project, including the energy audit, financing package, contracting package, and the installation of the materials. The landlord, however, obtains the loan from the lending institution. The incentive for the landlord is that the loan is obtained at below market rates through the development of a loan interest reduction plan. In the energy service company model, a local agency sets up an energy service company (ESCo) to actually deliver weatherization services to a landlord. This ESCo provides the technical assistance elements of the first two models and directly enters into an energy service contract with the landlord. This particular model serves two purposes: (1) it tests the energy service company concept in a nonprofit setting; and (2) it demonstrates an economic development possibility for weatherization subgrantees.

The WAP projects address these specific questions through the models being conducted: (1) Do the financing models succeed in getting more multifamily rental units weatherized?; and (2) Do the financing models result in weatherization efforts funded substantially by the private sector?

Although each model differs in some respects, there are some common objectives against which they can be measured. Those objectives are to: (1) Influence landlords to participate; (2) Provide enough benefits to permit payback of costs; and (3) Act as a potential catalyst for economic development activities.

The innovative financing projects of WAP represent a blending and accommodation at two levels of interest: national and local; and public and private.

DOE INFORMAL INNOVATIVE FINANCING GROUP

This informal group is a forum for DOE staff working on innovative financing to meet and share information on projects, keep one another abreast of developments in innovative financing being developed by the different offices as well as to provide an opportunity to hear from guest speakers on the state-of-the-art in financing. Recent sessions have included guest speakers on software programs for financial analyses and insuring energy service arrangements. DOE participants have included staff from a wide range of DOE offices which are actively engaged in various aspects of innovative financing.

INNOVATIVE FINANCING SURVEY PROJECT

This survey project queries participants of the WAP and ICP programs and utilities nationally regarding their activities in innovative financing. No information base currently exists which provides the status of innovative financing in the sectors covered by WAP and ICP at the State and local levels, and utilities nationally.

WEATHERIZATION ASSISTANCE PROGRAMS INNOVATIVE FINANCING INITIATIVE SHARED SAVINGS - MICHIGAN

This project, being managed by the State of Michigan and the city of Ann Arbor, is designed to demonstrate the use of shared savings financing to finance energy efficiency improvements in multifamily housing. This will further test whether a municipality or a municipally sponsored nonprofit corporation can combine the shared savings financing mechanism and available public funds designed for housing rehabilitation to finance energy efficiency improvements in multifamily housing. If so, this approach provides an alternative to for-profit energy service companies which are reluctant to enter into shared savings deals for smaller, older multifamily structures with a high proportion of low-income tenants. This project will further Ann Arbor's and the Michigan Energy Administration's expertise in applying shared savings financing to the residential sector and provide other cities and States with a comparative analysis of shared savings financing approaches for low-income, multifamily housing. This is a cooperative effort between the Michigan Department of Labor, Bureau of Community Services which administers the WAP, and the Energy Administration of the Michigan Department of Commerce. A "HOW TO..." publication will be completed in order that the best features of this model may be replicated by other interested cities and States.

INNOVATIVE FINANCING INITIATIVE, SHARED SAVINGS - MINNESOTA

The Minnesota Department of Economic Security, Weatherization Office is assisting an eligible landlord in securing the services of a commercial energy services/shared savings company; will monitor the progress of the shared savings company; conduct an independent energy audit; monitor the installation of the measures and track the progress of the project during the life of the agreement or payback period. The State is preparing a "HOW TO..." manual for other landlords to provide guidance and assist them in securing their own deals with commercial firms. Two bids have been received and are being analyzed. The State will assist the landlord in evaluating the two proposals. It is anticipated a contract will be awarded and work on the building completed in 1986.

INNOVATIVE FINANCING INITIATIVE, ENERGY SERVICE COMPANY/BUSINESS DEVELOPMENT - NEW YORK

This model is being conducted in Syracuse, New York by P.E.A.C.E., Inc., the local community action agency, in conjunction with the New York State Department of State Assistance. The purpose of the project is to develop a pilot program to sell energy conservation project management and financing services to owners of multifamily apartment buildings and to determine whether this program can be replicated elsewhere. Using planning funds from the U.S. Department of Energy, P.E.A.C.E. will form an Energy Service Company subsidiary, identify potential buildings, conduct audits, work with engineers and contractors to provide both the diagnostic engineering, design and specifications, and the construction, maintenance and supervision for energy retrofit projects, identify potential lending institutions and other sources for capitalization of energy conservation activities and develop complete financing packages for building owners, provide construction management and post construction monitoring; and prepare a final written report detailing the project stages in the form of a "HOW TO..." document. It is estimated that in order to be self-sufficient within two years the energy service company will have to complete 9 buildings in 12 months. Four have already been identified as good candidates and one is being expedited for completion in 1986.

INNOVATIVE FINANCING INITIATIVE, SHARED SAVINGS - OREGON

Early analysis of the Minnesota shared savings project indicated that enticing a shared savings company to the low-income, multifamily market was perhaps one of the greatest challenges facing the demonstration. In Portland, Oregon, Western Enertech, a wholly owned subsidiary of Portland Gas and Electric, was interested in exploring the multifamily market. The Department of Human Resources, State Community Services Program which implements the weatherization program in Oregon, and Western Enertech are entering into preliminary activities to determine if buildings identified by a local agency would be of interest to this commercial shared savings firm. Preliminary energy audits are the first step in assessing the savings potential of the buildings before a model in Portland is pursued further. Initial indications are positive. This approach of having a local agency work with a local energy services company/shared savings company holds promise for many agencies nationwide. Buildings selected would be weatherized/retrofitted with private funds rather than DOE funds.

INNOVATIVE FINANCING INITIATIVE, BANK PARTICIPATION - PENNSYLVANIA

This model is being conducted in Luzerne County, Pennsylvania by the Commission on Economic Opportunity which implements DOE's Weatherization Assistance Program. The Bureau of Human Resources of the Pennsylvania State Department of Community Affairs administers the WAP statewide and administers this project for DOE. Using no Federal funds, this model will weatherize a privately-owned master-metered low-income building. The local agency has developed a financing model based on a loan interest reduction program to be offered through a local bank. Pennsylvania Power and Light will contribute to the model's financing and will receive State tax credits for their efforts through the Neighborhood Assistance Tax Credit Program. PP&L will also assist in auditing the building. The local agency will prepare a "HOW TO..." which is a log of key activities of the project, including incentives and barriers to be used by other interested parties in order to replicate the model's best features. Bids have been received on the building. It is anticipated that a contract will be awarded and work on the building completed early in 1986.

ENERGY MANAGEMENT AND EXTENSION PROGRAMS

The Energy Management and Extension Division supports two State grant programs, the State Energy Conservation Program (SECP) and the Energy Extension Service (EES), which provide funding and technical assistance to support State energy efficiency efforts. A major thrust of the Division is to encourage States to leverage their Federal funds to attract more private sector resources and audiences for energy efficiency efforts. By providing technical assistance and training to the States, the Division helps to promote more opportunities for public-private sector cooperation.

Innovative financing, a leading example of the leveraging of non-Federal resources, is being promoted widely by DOE and an increasing number of States to both public and private building owners. Although a limited number of innovatively financed projects were evident only a few years ago, today a strong State-sponsored network is growing among the States to encourage and assist other States in promoting the use of shared savings and other innovative financing techniques. Michigan, with encouragement from DOE, has been a leader in stimulating that network.

Many State innovative financing efforts are supported by either EES and SECP grant funds or monies from petroleum violation escrow (PVE) funds used through the EES and SECP programs. Such expenditures depend on prior DOE Support Office and Headquarters approval. Although the Energy Management and Extension Division currently does not fund directly any specific innovative financing projects, the office does facilitate the exchange of information on such opportunities and successes between the States and offers encouragement and assistance to promote expanded use of such financing approaches. For example, DOE sponsored bi-regional/State meetings of EES and SECP program managers feature discussions of innovative financing activities on-going or planned by States.

Based on DOE encouragement, a number of States have sponsored conferences and demonstrations to introduce the innovative financing concepts to building owners, and several State energy offices have influenced the passage of legislation that allows such entities as municipal governments to enter into multi-year performance contracts. In several instances, State energy office staffs have facilitated the formulation of agreements between building owners, energy service companies, and financiers. And, in one State, a State agency is acting as the third party to provide financing for State institutions to fund energy efficiency improvements, thereby retaining all profits that would accrue to the third party and reducing the payback period.

CALIFORNIA: SAN FRANCISCO COUNTY PUBLIC HOUSING/TENANT DEMONSTRATION

This project, sponsored by the California Energy Commission, is designed to leverage private capital to achieve energy conservation in the residential rental sector. The focus area of this project is in public housing for the City and County of San Francisco. The project provides funds to test an innovative financing, retrofit, and incentives project for tenants, landlords, and managers of public housing. So far, this project has resulted in boiler retrofits, improvements in lighting and insulation, and new solar hot water heating for 1,000 apartment and hotel units operated by San Francisco Public Housing. The average energy saving per unit is 157 Therms and 562 Kilowatt hours.

CALIFORNIA: SMALL CITIES ENERGY REVOLVING FUND

The project, sponsored by the Governor's Office of Planning and Research and the Southern California Association of Governments, involves a customized energy efficiency implementation plan for local governments to reduce energy bills through no-cost and low-cost measures. In the pilot project, the Southern California Association of Governments (SCAG) offered free building audits to three small Southern California cities to determine where energy costs could be reduced. Based on the audits--conducted by the local utility companies--SCAG developed a computerized bill monitoring system to establish levels of savings. The cities pay nothing for these services initially; however, they pay one-half of their first year's savings from the program into the revolving fund. This money is used to provide the same low-cost services to other cities in the region in coming years. The clients in this pilot program are Ojai, population 7,300; South Pasadena, population 23,000; and El Segundo, population 14,000.

The program was designed to overcome several perceived barriers to energy efficiency in small cities, including lack of knowledge regarding the impact of energy costs on city operating expenses and the potential for sizable dollar savings through energy management. Also addressed by the program was the inability of many small cities to afford an energy consultant or city staff necessary to begin to manage energy use in city facilities.

CONNECTICUT: SHARED SAVINGS PILOT PROJECT

The State Energy assisted in the passage of legislation to allow third-party financing for State facilities. The Office then worked with the Department of Corrections to design a pilot project featuring third party financing of energy improvements and installation of an energy management control system at the Somers Correctional Institution. This project was designed to test whether shared savings will work in a State-owned facility and to try to develop incentives to save energy by sharing savings with the institution.

DELAWARE: SHARED SAVINGS THROUGH THIRD PARTY FINANCING

Delaware Technical and Community College was in need of a heating system retrofit, the cost of which could not be covered with their available funds. The only immediate solution for obtaining the necessary funds would have been to be included in the State Bond Bill, for which they had a 50-50 chance of eventually getting the funds necessary (perhaps after waiting several years) to finance the project. With the assistance of the State Energy Office staff, a bill was passed by the State Legislature that approved the use of shared savings arrangements instead. The State Energy Office staff then worked with the College to put together a third party financing arrangement, whereby the utilities provided the up-front funds, which were repaid from energy saved, and the work was done.

FLORIDA: STATE AGENCY DEMONSTRATION

This project involves the installation of cogeneration equipment at two state universities, using shared savings-third party financing. The Governor's Energy Office has hired contractors to broker the projects, monitor their progress, and write a procedural manual. The universities lacked the capital to undertake the necessary purchase and installation of equipment.

FLORIDA: DADE COUNTY DEMONSTRATION

Dade County is contracting with an energy services company to implement a shared savings program involving three county buildings. The Governor's Energy Office contracted with Florida Atlantic University to monitor implementation and operation of this demonstration and prepare a procedural guide for other local governments.

IOWA: ENERGY CONSERVATION LEASE PURCHASE PROJECT

In 1983 the Iowa Energy Policy Council (IEPC) and State legislature invested $2.4 million of Petroleum Violation Escrow Funds, under the State Energy Conservation Program (SECP), into demonstration activities on State and local government building analyses and conservation measures. Part of the desired outcome was to show legislators the viability and cost effectiveness of investments in energy efficiency improvements for State buildings. This demonstration resulted in the authorization for the innovative financing program, which will spend $10 million annually for four years to implement energy conservation projects in State buildings. A financial company will issue certificates to investors (similar to bonds) which will pay for the costs. The investors (State agencies) are assured repayment, not through the State's obligation, but through guaranteed or insured savings generated by the energy efficiency improvements financed by the project.

KENTUCKY: INNOVATIVE FINANCING CONFERENCE

DOE SECP funds were used to organize and execute a conference designed to share up-to-date information from Georgia's experience with a recent shared savings success story. 120 representatives from Kentucky schools and hospitals attended this conference.

MAINE: AN ACT TO AUTHORIZE THE USE OF ENERGY SERVICE COMPANIES AND THIRD PARTY FINANCING FOR CONSERVATION IMPROVEMENT AT STATE FACILITIES

The Act enables the State to bring in energy service companies to do energy conservation projects for State-owned buildings. Maine Office of Energy Resources staff were involved in drafting the legislation. Maine had a small source of funds to initiate energy saving projects in State buildings. The State energy office sponsored the legislation.

MASSACHUSETTS: INNOVATIVE FINANCING PILOT PROGRAM

The Massachusetts Executive Office of Energy Resources has hired a consultant to analyze a variety of traditional and innovative financing mechanisms available to local governments and to provide assistance to at least 10 (possibly as many as 15) communities in assessing the merits of proposed energy efficiency measures and selecting contractors. The goal of this project is to install capital measures in these communities using innovative financing techniques, and then to encourage the use of innovative financing by the local communities. The information gained in this project will be of benefit to other local governments.

MICHIGAN: ENERGY EFFICIENCY IMPROVEMENTS FINANCING PROJECTS

The State of Michigan is co-sponsoring 6 demonstrations of energy efficiency improvements financed using the shared savings approach in a total of 17 school buildings, 3 municipal government buildings, 1 small business facility, and 218 multifamily housing units. The project will develop educational materials for use by decision-makers in other public and private facilities considering energy efficiency improvements; will demonstrate the viability of financing public and private building energy efficiency improvements using the shared savings approach; and will develop a capacity to provide the necessary technical assistance for other buildings. The sponsors of this project include the Michigan Energy Administration, Michigan School Business Officials, Michigan Municipal League, Small Business Association of Michigan, City of Ann Arbor, and the owners of participating buildings.

MISSISSIPPI: ALTERNATIVE FINANCING DEMONSTRATIONS

The Mississippi Department of Energy and Transportation, with the assistance of the DOE Atlanta Support Office, is working with public and nonprofit agencies to help them find ways to purchase energy equipment and services for their buildings other than through the traditional capital budgeting process. Alternative methods include shared savings, true leases, municipal leases, and lease-purchases. The Legislature passed a law to authorize this approach. A financial analysis is conducted to determine the best process for each agency. Demonstration projects for different sectors using different financing methods are included to prove viability and to show how the process will work. Agencies will receive help in developing model documents.

NEW JERSEY: SYMPOSIUM ON ALTERNATIVE FINANCING

New Jersey Department of Energy sponsored a conference to explain alternative financing approaches to decision-makers in municipalities, school districts, and hospitals; and to introduce those decision-makers to equipment and service providers. The New Jersey Department of Energy is providing technical assistance, such as this conference, to any entities that could be potential participants in innovative financing projects.

NEW JERSEY: TECHNICAL ASSISTANCE TO PROMOTE INNOVATIVE FINANCING PROJECTS

The New Jersey Department of Energy is supporting three staff members who provide technical assistance to facilities managers interested in entering into innovative financing agreements. The State also assisted in the preparation and passage of legislation that made such agreements possible.

As a result of this technical assistance, energy efficiency improvements are now underway in a number of projects including the Mercer County Vocational School, Edgewater Park Municipal Building, several municipal buildings in the City of Trenton and the County of Camden, and the John E. Runnells Hospital.

NORTH CAROLINA: WATER WASTE TREATMENT, CITY OF SANFORD

As a result of a Water Waste Treatment Audit conducted under the SECP, the City of Sanford obtained a consultant to install a computer-based processing system that will operate aerators which add oxygen to water on an "as needed" basis as opposed to 24 hours per day. The City invested $45,000 for the installation and programming of the system. The consultant guaranteed that the City would save a certain amount of kilowatt-hours. If those kilowatt-hours are not saved, the consultant agreed to buy back the computer system including the cost of disconnection. In the first six months of operation, the City had saved $22,000. The North Carolina Department of Commerce/Energy Division, and the city of Sanford, sponsored this project.

RHODE ISLAND: STATE OFFICE BUILDING RETROFIT DEMONSTRATION

The Rhode Island Statewide Energy Conservation Office (SECO) is using Petroleum Violation Escrow funds (under the State Energy Conservation Program) to support a demonstration project featuring installation of commercially available energy saving techniques appropriate to office buildings. The project will provide audit and installation of energy saving improvements in five of the more than 700 state-owned facilities and will serve as an example for both public and private sector facility owners and managers. The audit and installation work will be financed through a shared savings agreement with an energy services company that will be paid based on the savings resulting from the building improvements. The demonstration is being done to test the shared savings approach to funding energy improvements. The State had no source of funds to initiate the project without using such an approach.

SOUTH CAROLINA: INNOVATIVE FINANCING CONFERENCE

The State of South Carolina sponsored a conference in March 1985 to promote the innovative financing approach for energy efficiency improvements.

TENNESSEE: INNOVATIVE FINANCING STUDY

A consultant was hired by the Department of Economic and Community Development, Energy Division to survey Tennessee businesses in certain Standard Industrial Classification codes concerning energy use and financing. Of the 1,100 business surveyed, 178 responded and 44 percent of these indicated an interest in using innovative financing. The Tennessee Energy Division plans to continue contact with them to encourage their taking advantage of this type of financing.

TEXAS: ENERGY EFFICIENCY IMPROVEMENT PROJECTS

In May 1985, the Texas legislature approved energy efficiency projects for State institutions in a revenue bond package to be issued by the Texas Public Building Authority. The legislation specifies 12 sites for energy efficiency projects, totaling $12 million. An additional $900,000 was provided for engineering analyses, using Petroleum Violation Escrow Funds.

The 12 sites were selected on the basis of engineering analyses of 400 State buildings. Estimated savings from the projects are $6 million per year. The unique aspect of this project is that a State agency has been designated as the third party and all profits will be retained by the State. This project will demonstrate to State institutions the advantages of making energy efficiency improvements. The project is being managed by the Energy Efficiency Division of the Public Utility Commission of Texas.

WASHINGTON: INNOVATIVE FINANCING DEMONSTRATION PROJECT

The Washington State Energy Office is sponsoring a demonstration project to orchestrate contracts between two local governments and energy service companies. A broker service delivery model was selected which provides an advisory service for the local governments and helps them solicit and evaluate contractor offers. A case study program evaluation will be conducted. Information learned from the project will be distributed to building owners through a guidebook and a series of seminars.

OTHER DOE INITIATIVES

The following projects have been undertaken by other components of DOE.

CONVEST

CONVEST, developed under the auspices of DOE's Office of Policy, is an IBM PC-compatible software program which is designed to help the institutional energy user save money through comprehensive analysis of conservation investment alternatives. It allows the institution to analyze alternative conservation investment options including third party financing, commercial loans, municipal bonds, government grants, internal financing or any combination. CONVEST analyzes the costs and benefits to each participant in the investment: the institution or first party; the energy service company or second party; and the supplier of capital or third party.

DEPARTMENT OF ENERGY IN-HOUSE ENERGY MANAGEMENT PROGRAMS

The Office of Project and Facilities Management, under the Director of Administration, is currently attempting to resolve procurement and legal barriers to innovative financing. This type of financing could supplement funding of the In-house Energy Management Program, which provides funds for energy conservation projects for DOE facilities.

Because of the research, development, and production nature of DOE facilities and the associated large swings in energy use, the use of innovative financing for energy conservation retrofit projects for DOE facilities appears to be limited. Innovative financing alternatives for energy supply projects, such as solid waste fired steam plants and cogeneration, show more promise, and are being studied. The contractual vehicle, length of contract, termination issues, and other constraints are being studied for such innovative financing arrangements. Initial efforts indicate that there are no significant legal or procurement barriers to the lease of personal property for energy conservation.

The Department is also studying barriers, problems, strategies, procedures, and possible legislation needed to accomplish certain energy conservation retrofits as shared savings projects. The savings contracts would have private sector investors agree to finance energy conservation retrofits with repayment coming solely from the savings generated. Since many DOE facilities are subject to signifianct swings in energy use due to programmatic changes, continual contract negotiations to determine savings resulting from retrofits may be necessary. Further, because there is a lack of metering in many of the DOE facilities, often there is no baseline energy consumption upon which to base contract negotiations for these facilities. Thus, the possible use of shared savings contracts appears to be limited.

BONNEVILLE POWER ADMINISTRATION PROGRAMS

The Bonneville Power Administration (BPA) is charged with acquiring all cost-effective conservation resources under the Pacific Northwest Electric Power Planning and Conservation Act of 1980. In making these acquisitions, BPA has attempted to match the most appropriate financing vehicle with the individual energy efficiency programs of each consuming sector. To this end, studies of each sector and the financing options have been completed. These studies have reflected BPA's mandate to operate in a businesslike fashion to accomplish the cost-effective acquisition of electricity resources. While the bulk of BPA's programs continue to be financed through the traditional route of borrowing from the U.S. Treasury, a variety of financing approaches have been developed and tested in the various end-use sectors. These programs have been specially designed to encourage or finance energy efficiency improvements in the Northwest, where energy costs tend to be considerably lower than in the rest of the continental U.S. Since most innovative financing approaches are dependent upon achieved savings, BPA has had to develop some region specific variations to provide private sector incentives where energy costs, and consequently potential savings, are lower than elsewhere.

The specific BPA financing programs, by sector include:

- o Residential--Public utilities issue tax-exempt debt while BPA backs the bonds. The proceeds are used to finance BPA's Residential Weatherization Program. In the future BPA will restructure this program so that utilities arrange the financing form most appropriate to them while BPA purchases specified kWh savings over an agreed upon term.

- o Commercial--In the Purchase of Energy Savings Program, sponsors, typically energy service companies and utilities, arrange for the delivery of energy efficiency, including financing, to commercial facilities. BPA then purchases the resulting kWh savings at a specified price over a set term. BPA is also initiating a Commercial Financial Incentives Program where interest rates on energy efficiency loans made by financial institutions in the Northwest will be subsidized.

- o Industrial--BPA is initiating a Purchase of Energy Saving Program similar to the commercial sector where kWh savings from approved transactions will be purchased from sponsors.

- o Institutional--Studies have indicated there is a need for technical assistance for institutions to arrange innovative financing transactions. Recently BPA completed development of a model to have expert consultants assist institutions develop financing arrangements on a contingency fee basis. BPA plans to develop a technical assistance program in this area.

- Regional Finance Corporation--A study of the feasibility of creating a Regional Finance Corporation to provide financing for energy efficiency programs in the Northwest was conducted. Results indicate that financing is available for all planned conservation programs.
- Integration of Financing into Long-Term Planning Process--BPA is completing a project to model the integration of financing into all long-term conservation planning in all consuming sectors.

ATTACHMENT A

The following definitions relate to a variety of financing approaches currently available for energy conservation improvements. Many of these definitions have been adapted from Management Finance by J. Fred Weston and Eugene F. Brigham, The Dryden Press, 1981. (Some of the references to tax shelters may not apply to tax-exempt institutions.)

Closed End Lease: In effect, the same as a lease/purchase, whereby the lessee agrees to make payments for a set period of time, at which time the lessee either owns the property, or has the right to purchase it at an already agreed-upon price. The payments on a closed end lease are structured so that the lessor covers the cost of financing and acquiring the property (and any service or maintenance, if the lease covers that), as well as a return on investment. For tax purposes the lessee is considered the owner of the property, so the lessor can't depreciate the property, or make use of other tax shelter provisions.

Energy Service Company Agreements: Contracts with providers of energy management services who may, depending upon the type of agreement, evaluate a building's energy use, make necessary improvements in equipment and procedures, pay for the fuel and utilities, and provide an agreed-upon comfort level, for a fee that is usually set lower than the building's prior total energy-related costs.

Guaranteed Savings Arrangements: Agreements whereby a firm will guarantee that a piece of equipment (or a package of conservation measures) will achieve some minimum amount of savings over an agreed-upon period of time, or the firm will refund the difference between the actual and the guaranteed savings. These arrangements are usually part of a lease, or lease-purchase, agreement.

Lease: A method of obtaining the use of a building and/or equipment without a direct purchase, by agreeing to make regular payments over an agreed upon period of time. Lease payments by the occupant/user (lessee) would ordinarily cover the building/equipment owner's (lessor's) costs of acquisition and financing, and may or may not include such costs as maintenance and utilities. Some leases provide for the lessee to ultimately obtain ownership of the building/equipment while others do not. Depending upon the conditions of the lease, and the types of building/equipment, it may be possible for a lessor to take advantage of a number of tax shelter provisions (depreciation, interest deductions, etc.).

See also: Open ended lease; Closed end lease; Lease/Purchase; Tax exempt municipal leasing.

Lease/Purchase: An agreement whereby the lessee commits to "leasing" buildings or equipment for a set period, at which time the lessee can become the owner of the property, perhaps for a token amount (such as $1), or for a price agreed-upon in advance. For tax purposes such agreements are considered installment purchases, and the lessor therefore cannot make use of the tax shelter provisions available under other types of leases.

Open Ended Lease: An agreement to make regular payments for the use of a building and/or equipment for an agreed-upon period of time (with possible renewal options), but with no provision for the lessee to purchase the property at a future date for a set price. For the lessor to obtain full tax shelter benefits from leased property, the lessee can have no preferential claim on the property if and when it is disposed of by the lessor. There may be a provision to the effect that the lessee be given the opportunity to purchase the property at the end of the lease period "for fair market value", which theoretically, at least, would give other potential purchasers a chance to buy this property.

Shared Savings Agreements: Arrangements by which private sector investors agree to finance energy conservation improvements in institutional (or other) buildings with repayment to come (usually) solely from the savings generated by the improvements. In some cases the entire project is undertaken by a firm (a second party) which invests in, installs and manages the installation. In other cases, outside investors (third parties) will assume some, or all, of the financial obligations (and risks) and will hire a firm to do the installation and management (or the firm may assemble the investors by selling, or syndicating, interests in the project).

Tax-Exempt Municipal Lease: An arrangement whereby an organization which has tax-exempt status commits to lease property from outside investors who obtain tax-shelter benefits because the interest portion of the lease payment is tax-exempt to the investors (because it is being paid by a tax-exempt organization). In cases where the tax-exempt interest is the investors' primary concern, the lease may be structured as a closed-end lease, or lease purchase, whereby the lessee obtains ownership of the property at the conclusion of the lease agreement.

SCHOOL OF MINES AND ENERGY DEVELOPMENT
NATURAL
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CENTER The University of Alabama Box 6282 University, Alabama 35486 Tel. 205/348-4520
ACTS 243-4520

Water Resources Program
Biomass Program
Environmental Program
New Energy Sources Program

March 3, 1986

The Honorable Don Fuqua
United States House of Representatives
2269 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

Enclosed is a written statement in support of funding for Thermal Energy Storage in the Department of Energy budget for FY 1987. I have discussed this matter in detail with Bill Harvey who has been to Tuscaloosa and has personally seen some of the Thermal Storage Research we are doing here.

We would appreciate your Subcommittee on Energy Development and Applications giving our arguments serious consideration.

Sincerely,

C. Everett Brett

C. Everett Brett, Ph.D.
Director, Natural Resources Center

CEB:sw

Enclosure

WRITTEN STATEMENT

by

Dr. C. Everett Brett, Director

Natural Resources Center

The School of Mines and Energy Development

The University of Alabama

to the

Subcommittee on Energy Development and Applications

House Committee on Science and Technology

Hearings on Fiscal Year 1987 Authorization for the

Department of Energy Thermal Energy Storage Programs

March 3, 1986

This statement pertains to FY 1987 Department of Energy R & D Appropriations for Thermal Energy Storage Research. The University of Alabama strongly endorses the continuation of thermal energy storage research at a modest level of funding and offers recommendations whereby an effective R & D program can be continued at a funding level below that appropriated to The Department of Energy in FY 1986.

The Natural Resources Center at the University of Alabama has been responsible for alternative energy and environmental research since 1969 and as a division of the School of Mines and Energy Development since 1978. The Natural Resources Center develops, conducts, and supports alternative energy and environmental research which responds to state, regional, and national needs. To accomplish these goals, the University of Alabama for many years has committed substantial funds and human resources to research directed at finding ways of reducing the use of and conserving the nation's energy resources and reducing the environmental impact of producing energy. The Natural Resources Center in cooperation with the Department of Mechanical Engineering has been conducting research in thermal energy storage in aquifers since 1977.

Thermal energy can be stored in aquifers either as heat for winter heating or as chill for summer air conditioning. Significant attention has been given by the Department of Energy since 1976 to the storage of hot water in aquifers for heat recovery on an annual cycle. Less attention has been given to the prospect of storing cold water generated in the winter time for summer air conditioning. The Natural Resources Center has concentrated its efforts on research pertaining to the storage of chilled water for air conditioning because of the high electrical energy demands for air conditioning in the South. Air conditioning occurs the year around in large buildings, even in the cold northern latitudes of Canada because of the internal loads generated by large major buildings. Aquifer air conditioning consists primarily of pumping water in the winter time from an aquifer from one set of wells and cooling it by exposure to cold air temperatures and returning it to the aquifer in a second set of wells. Flow between the two sets of wells creates a storage volume that contains the chilled water on an annual cycle. In summer, the flow is reversed and the chilled water is pumped back to the surface and used for air conditioning buildings. After the water passes through a building and is warmed, it is pumped back into the original set of wells and the cycle is subsequently reversed. Our results through theoretical modelling and through experience with a prototype air conditioning systems constructed in the Parisian Department store in Tuscaloosa, Alabama, and in the University of Alabama Student Recreation Center show that a minimum of 50% of the air conditioning energy and cost can be saved as compared to conventional electrical air conditioning systems. The cost of purchasing and operating expensive chillers is eliminated. The main components of the system are the cooling towers or cooling ponds used to chill water, the wells, pumps, the connecting piping, the aquifer itself, and controls to operate the system. Our studies show further that in some systems as much as 80% of the cost of electricity and energy can be eliminated, and that 70% of the nation's population is located in areas where aquifers are available for thermal storage.

In addition to the aquifer air conditioning systems constructed for Parisian Department Store and the University of Alabama Student Recreation Center, a system has been designed by the University for the General Motors Rochester Carburetor Plant in Tuscaloosa for which bids have been received. The front end costs as indicated by the bids show a payback of 6 years. Currently, the project is in a holding status because General Motors has a payback limitation of 4 years for all energy conservation systems. The system has since been redesigned incorporating the experience gained in the original design and a three to four year payback is expected for the new design. However, General Motors Corporation, although it has encumbered funds to build the system (700 tons @ $250,000), is reluctant to go forward with the construction unless the Department of Energy is willing to participate in a monitoring program to evaluate the operational effectiveness of the system. They feel there is too much risk to build the system without a means of evaluating its operation. Should the system prove effective, as anticipated, General Motors Corporation has indicated that they would have a strong interest in using this energy conserving technology throughout their industry. This would be an outstanding opportunity for joint federal and private enterprise research.

The aquifer air conditioning systems at the Parisian Department Store and at the University of Alabama Student Recreation Center were constructed without federal funds. The system at the General Motors Carburetor Plant would also be constructed solely from private industry resources.

In the late 1970's DOE constructed a large aquifer air conditioning system in New York which ultimately proved to be a failure. Because the Parisian system worked, DOE invested a modest sum of money for monitoring the system. During the course of this monitoring the Student Recreation Center System was constructed and has been operating successfully for over three years without serious problems. DOE is currently investing a modest sum in monitoring the Student Recreation Center but at a level that limits the amount of information that can be gained. The University took some risk to construct this system, and now we are learning why it is effective when earlier systems have failed. We now know that the systems will work and that the cost savings are real, and we are continuing to develop designs that minimize front-end costs for construction to make the payback increasingly attractive to industry.

In addition to the aquifer air conditioning system just described the Veterans Administration Hospital in Tuscaloosa is planning the renovation of several of its buildings. This renovation includes energy conservation renovation and is planned to include aquifer air conditioning as part of the work. These plans have been reviewed by the Veterans Administration Engineering Division in the Washington D.C. central office and have been conceptually approved for the Tuscaloosa site. This would be an ideal site to demonstrate the commercial application of aquifer air conditioning because of the benefits that would accrue to the Veterans Administration and because, in this particular case, four of the treatment buildings would be incorporated into a single system with the storage volume located in a large rectangular area between the four buildings. It would be very beneficial for the Seasonal Storage Program in the Department of Energy to monitor this new system at the Veterans Administration Hospital because it would be a fourth generation design benefiting from the design experience at the General Motors Carburetor Plant. We are reluctant to go forward with the Veteran's Administration System, however, without having learned from the construction of the system at the General Motors Carburetor Plant. Although the Veterans Administration could tolerate a 6-year payback for the construction of their system, it is probable that a system with as low as a three or four year payback could be designed based on criteria learned from the General Motors Carburetor Plant.

The future of aquifer air conditioning and the large benefits that can accrue from this commercial energy savings strategy depends on progress developed at the General Motors Carburetor Plant in Tuscaloosa. A successful experience at this plant could result in the construction of aquifer air conditioning systems throughout the General Motors organization and similar installations at federal facilities such as VA Hospitals, military bases, and other large federal installations which could significantly reduce the government's energy bill.

In spite of the significant potential for thermal storage to conserve energy on a national basis, the Department of Energy has reduced funding in this area in preference to other programs. These funding reductions have been the result of total program reduction in recent years. For instance, in FY 1981, Thermal and Mechanical Storage (now Thermal Storage) received

23.6 million dollars and the Batteries program received 27.3 million dollars. By FY 1985, Thermal Storage received 2.3 million while the Batteries Program received 16.8 million. Subsequently, DOE recommended termination of the Thermal Storage Program.

Large sums of money have been expended to produce minor improvements in some chemical battery systems as compared to progress made in Thermal Storage. Research in Seasonal Storage, particularily cold water storage in aquifers for air conditioning, has made some large strides on very limited funding. Most of this funding has come either from private enterprise or state sources. So far, only $100,000 has been committed to the current study of cold water storage in aquifers for air conditioning. This is to monitor the system at the University of Alabama Student Recreation Center which was constructed at no cost to the government. Already, results from this system is providing information which could make the application commercial in two to three years. However, there are still too many unknowns, and enough risk to keep the technology from being attractive for commercial application.

The applications of aquifer air conditioning are economically limited to a minimum of about 150 tons. Since the application is suited primarily for very large installations such as hospitals, factories, and major buildings, the savings of natural resources through the reduction of energy usage and the cost savings to commercial users is very large. Although we have some experience in operating these systems at the Parians store in Tuscaloosa and at the University Student Recreation Center, and know that they will work, and that the savings are real, we are still learning how to design a system at the minimum front-end cost for construction to make the payback more attractive to industry.

In addition the technology will have the effect of reducing the total demand for electricity, thus limiting the need for new electrical generating equipment and potentially limiting environmental degradation caused by generating electricity (acid rain, etc.). It also load-levels by shifting the demand for electricity for air conditioning from summer to winter.

Before making a recommendation for FY 1987 funding, the funding for FY 1986 should be reviewed. In FY 1986, Congress appropriated $7 million for Thermal Storage in the language of the bill. However, the appropriation tables showed $3 million for Thermal Storage. DOE elected to ignore the $7 million appropriation in the language and chose to commit $3 million as reflected in the tables. Of the #3 million dollars, only $1.6 million was actually committed to Thermal Storage. The $1.6 million was distributed as follows:

Industrial Storage - $300,000 ORNL
Diernal Storage - $700,000 ORNL
Seasonal Storage - $600,000 PNL

The remaining $1.4 million of the $3 million appropriation was assigned to:

Hydrogen - $1,000,000
Solar Thermal - $200,000 SERI
Tax - $200,000

Hydrogen manufacture and solar thermal research is only marginally related to thermal storage research.

Even though the Department of Energy chose to ignore the $7 million appropriated in the language of the bill, that level provides a modest funding for support of a viable Thermal Energy Storage Program. With the problems confronting Congress relative to the national deficit and passage of the Gramm/Rudman/Hollings Act, we recommend a FY 1987 Thermal Storage budget of $6 million: this is 85% of the FY 1986 budget as appropriated by Congress in the language of the bill. Even though the program is currently being maintained at essentially a $1.6 million level, the recommended level will maintain a steady rate of progress toward the development of a strong technological base and commercialization of the technology which promises a very high energy conservation potential. A core program can be maintained if appropriate adjustments are made which can show significant progress on an annual basis. We recommend the following specific programs for Thermal Energy Storage:

Industrial Storage - $2.5 million ORNL
Seasonal Storage - $2 million PNL
Diurnal Storage - $1.5 million ORNL

These recommendations, although reduced, are in keeping with the levels appropriated by Congress for FY 1986.

The University of Alabama has been deeply involved in improving our research base in thermal energy storage; hence, we offer our thoughts regarding the priorities for Thermal Energy Storage research as a national program. In addition to our own laboratory and field research efforts, we continuously monitor activities relating to other technologies, research findings, environmental concerns and economic factors that impact the utilization and commercialization of thermal storage technology. We acknowledge that the University has a vested interest in the Thermal Energy Storage Program as described above since we have already made so much progress without federal support. We consider the development of this technology as essential to national energy conservation. The University is not directly involved in the Industrial or Diurnal Storage programs conducted at Oak Ridge National Laboratory, but both programs are extremely important to energy storage and the future of energy efficiency development in the United States. The Industrial Storage Program is working with near-commercial technology to capture waste heat and recycle it in manuacturing processes. As you know, the United States Industries are among the most inefficient in the world, and part of their inability to compete worldwide is their high cost for energy. An example is the heat loss in kilns (brick, wood, etc.), foundries, and other large heat demand industries. We are also very impressed with research strides that have been made with Diurnal Energy Storage which involves the load leveling strategies such as generating ice at night for daytime air conditioning. Much of the diurnal technology is being applied commercially but many new strategies need to be developed and evaluated in this area.

The University of Alabama through the School of Mines and Energy Development and the College of Engineering strongly endorses continued funding of the Thermal Storage Research Program especially in the areas of Industrial Storage, Seasonal Storage, and Diurnal Storage, and urges the appropriation of a very modest $6 million for its continuation in FY 1987.

EDA

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COMMITTEE ON SCIENCE
AND TECHNOLOGY

Federal Systems Department/3M

220-4E-01 3M Center
St. Paul, Minnesota 55144-1000
612/733 2063

3M

February 25, 1986

Mr. Don Fuqua, Chairman
House Committee on Science and Technology
2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Sir:

The subject of Solar Energy Development and its future is schedulued for discussion at your upcoming February 27-28, 1986, meeting. 3M would like to make the following recommendations and observations.

3M has participated in the solar energy and related products field for several years. Research and Development has focused on the areas of reflective films, fresnel lensing for solar concentrators, photovoltaics, and other areas. In all cases, these activities are still in an investment phase. The current market (or the projected near-term market) doesn't justify a large investment in these areas. The catalyst to keep our efforts advancing has been the DOE cost-sharing support of R&D. Such support allows the technologies to develop in advance of the developing market.

In the eventuality that serious cuts in R&D funding for Solar Energy Development are forthcoming from DOE, our future activities in many of the above areas will probably be curtailed until the market develops to support such activities. This situation would be very damaging to what is currently an exciting technology and eventually will become a national renewable energy resource.

3M would like to join with DOE in the evolution of solar energy related technologies and products. We must appreciate that this is still a long-term, high risk proposition and stable cost-shared funding from DOE will be absolutely mandatory for our continued high level of participation.

With a strong industry/DOE team, the prospect of technology developing sufficient to support the evolution of practical solar energy will, I am sure, take place at the highest possible pace.

Sincerely,

Robert F. Goff
Robert F. Goff
Solar Program Manager

dc: Mr. Tom Bevill, Chairman
Committee on Appropriations
Energy and Water Development
2362 Rayburn House Office Building
Washington, D. C. 20515

A REVIEW OF THE SOLAR THERMAL POWER INDUSTRY:

FUTURE OUTLOOK

DEPARTMENT OF ENERGY BRIEFING

JANUARY 27, 1986

CARLO LA PORTA
JEFFRY J. ERICKSON

SOLAR ENERGY INDUSTRIES ASSOCIATION

- GOAL

  TO REPEAT THE 1981 JET PROPULSION LABORATORY SURVEY OF THE SOLAR THERMAL POWER INDUSTRY TO PRESENT THE CURRENT STATUS OF THE INDUSTRY AND COMPARE IT WITH 1981.

- METHODOLOGY

  39 COMPANIES WERE IDENTIFIED AS REPRESENTING THE PREDOMINANT COMPANIES INVOLVED IN THE INDUSTRY. 37 OF THESE WERE INTERVIEWED, EITHER BY PHONE OR IN PERSON. QUESTIONS FROM THE 1981 JPL SURVEY AND NEW QUESTIONS ON TAX CREDITS, MARKETING, AND REASONS FOR LEAVING THE INDUSTRY WERE ASKED.

- DATE

  MOST OF THE INTERVIEWS WERE CONDUCTED OVER A FIVE WEEK PERIOD IN SEPTEMBER AND OCTOBER 1985. INDUSTRY REVIEWS WERE RECEIVED IN EARLY JANUARY 1986.

FINDINGS

Finding: 1 INDUSTRY COMPOSITION

The industry is composed primarily of small companies oriented almost exclusively to solar and large corporations with an interest in solar, but with a diversified base. The companies surveyed have an average of 19 employees working on solar thermal systems. These core companies are supported by five medium and large companies which produce solar components and materials while producing a variety of other products unrelated to solar energy (see Table 1). The vast majority of companies either spend all their R&D budget on solar thermal or they spend less than ten percent.

SOLAR THERMAL COMPANY TYPES

Number of Companies	Type of Company
11	Small solar or mostly solar company
6	Large diversified manufacturer
3	Large A&E or systems integrator
5	Medium and large manufacturer of specialty products (chemicals, engines, coatings, reflective surfaces, etc.)
2	Medium sized, diversified high tech research and manufacturing

Table 1

SOLAR THERMAL COMPANIES INTERVIEWED BY TECHNOLOGY

PARABOLIC DISH	PARABOLIC TROUGH	CENTRAL RECEIVER	A&E/SYSTEM INTEGRATOR	MISCELANEOUS
Acurex	Acurex			
Advanco				
Babcock & Wilcox	Babcock & Wilcox	Babcock & Wilcox	Babcock & Wilcox	
Barber-Nichols Engineering				Barber-Nichols Engineering (Rankine)
Bechtel Nat. Inc.	Bechtel Nat. Inc.	Bechtel Nat. Inc.	Bechtel Nat. Inc.	
		Black & Veatch	Black & Veatch	
				Dow Corning Corp. (Fluids, Coatings)
				DSET Laboratories, Inc. (Testing)
Entech	Entech			
		Foster Wheeler Dev. Corp.		
Garrett Turbines				Garrett Turbines (Brayton)
La Jet Energy Co.				
	LUZ			
McDonnell Douglas		McDonnell Douglas	McDonnell Douglas	
Mechanical Technology Inc.				Mechanical Technology Inc. (Stirling)
MTI Solar	MTI Solar	MTI Solar		MTI Solar (Black Chrome)
Olin	Olin	Olin		Olin (Chemicals)
Power Kinetics, Inc.				
Rockwell International		Rockwell International	Rockwell International	
Science Applications Int.	Science Applications Int.	Science Applications Int.		
Sanders Associates, Inc.				Sanders Associates, Inc. (Brayton)
Solar Kinetics, Inc.	Solar Kinetics, Inc.	Solar Kinetics, Inc.		
Solar Steam				
		Solar Power Engineering Co.		
Stearns-Catalytic Eng.	Stearns-Catalytic Eng.	Stearns-Catalytic Eng.	Stearns-Catalytic Eng.	
3-M	3-M	3-M		3-M (Reflective & Absorbine Materials)
United Stirling				United Stirling (Stirling)
21	11	13	6	10

COMPANIES EXITING THE BUSINESS SINCE 1981

PARABOLIC DISH	PARABOLIC TROUGH	CENTRAL RECEIVER	A&E/SYSTEMS INTEGRATOR	MISCELANEOUS
		Arco Pwr. Systems		
Boeing Engineering	Boeing Engineering	Boeing Engineering	Boeing Engineering	
Ford Aerospace			Ford Aerospace	Ford Aerospace (Stirling, Rankine)
	General Atomic		General Atomic	
Honeywell, Inc. TSC	Honeywell, Inc. TSC	Honeywell, Inc. TSC		
Jacobs-Del Solar Systems	Jacobs-Del Solar Systems			
		Martin Marietta	Martin Marietta	
		Nielsen Engineering	Nielsen Engineering	
		Westinghouse Energy Systems	Westinghouse Energy Systems	
Wyle Laboratories	Wyle Laboratories			Wyle Laboratories (Testing)
5	5	6	6	2

Finding: 2

COMPANIES OUT OF THE FIELD

Since 1981, thirty percent of the major companies involved in developing solar thermal technologies have discontinued their research activities in this field. The majority of these are large companies, mostly large diversified manufacturers. Their solar work formed only a small part of their overall operations. The two most common reasons for ceasing activity in solar thermal technologies were the decline of federal funding for research and the diminishing near term marketability of the technology. Lack of funds and signs that a market would be very slow in developing led these companies to redirect their attention and funds to other topics.

Finding: 3

INDUSTRY ACTIVITIES

The makeup of the industry has changed significantly. The percent of companies providing engineering services has dropped since 1981, from 74 percent to 48 percent while the percent of companies providing subsystems and components has risen, from 44 percent to 63 percent. There are fewer companies offering turnkey systems, but the percent of the industry remained unchanged (26 percent). Similarly, there are fewer companies doing R&D work for the government, but the percent of the industry did not change significantly (1981: 80 percent; 1985: 74 percent).

Finding: 4

PROGRAM GUIDANCE

When asked how much longer the DOE solar thermal program should continue, the average response was 17 years -- a significant increase over the 10.8 years in 1981 -- indicating that the industry generally believes the federal program should continue well into the 1990s and perhaps into the 21st Century. When asked what the federal budget for solar thermal systems should be, the average value was $57 million. In 1981, the industry average was $171.3 million.

Finding: 5

UTILITY OVERCAPACITY

One of the most important barriers to the solar thermal industry's success is utility overcapacity. Utilities, by and large, are not interested in new generating technologies, especially expensive, unproven ones. Even some utilities that do not have enough capacity are not interested in new generating technologies since they can buy power very cheaply from neighbors suffering from overcapacity. Thus in many areas the solar thermal industry must compete with existing sources of cheap power, not expensive new generating plants.

Finding: 6

CENTRAL RECEIVER NEEDS

Central receiver companies believe that their technologies could be marketable within the next five years but do not expect to see significant market development without increasing energy prices or increased support from the Department of Energy or both. Specifically, most companies believe that the risks for supporting commercial-scale plants, or even a significant scale-up of Solar One, are too high for the private sector to undertake alone at present. Without support by DOE the industry believes that the market will not develop until energy prices rise enough to balance the benefits with the risks -- and that may take 10 to 20 years or more. The central receiver companies exhibited great confidence in their technology and generally felt that no insurmountable technical barriers stand in their way. However they strongly believe that the industry needs at least one large new central receiver project to demonstrate new systems and designs on a large scale before they will be able to convince investors and utilities to invest in building the first commercial plants.

Finding: 7

DISTRIBUTED RECEIVER COMPANY NEEDS

Twenty-one companies are working on point focus distributed receiver systems or components. Eleven are working on line focus technologies. Point focus system manufacturers are generally optimistic about their technology and believe the market will develop and grow fairly rapidly if they receive federal support and incentives. Without such support they either expect to grow very slowly, expect to sell little or no systems while waiting, or expect to go out of business. Several believe that a three year credit of 25 percent would be sufficient to bring them to the point of self-sufficiency -- competitive in the present market without subsidies. The only company successfully marketing technology is Luz Engineering. The American companies have ceased any aggressive marketing.

Finding 8

INDUSTRY INVESTMENTS

On average, each company in the solar thermal power industry has made a cumulative investment of approximately $4.7 million of their own funds for advancing the technology over a period averaging 10 years. Some companies invested significantly more with the highest estimate at $35 million. If the three largest investors are eliminated from the equation, the industry average is $1.4 million. Cumulative federal R&D funding for these same companies averaged $9.9 million per company over ten years, or $4.6 million without the two largest companies. Comparing these figures makes it evident that the industry is undertaking significant cost sharing of solar thermal R&D -- between 30 and 50 percent of federal funding.

Finding: 9

FEDERAL R&D SUPPORT NEEDED

Interest in federally supported research increased in all areas. Testing prototypes and developing subsystems and components were identified as critically important and 96 percent of the industry believes federal research support is necessary in these areas. Interest in basic research increased 33 percent since 1981.

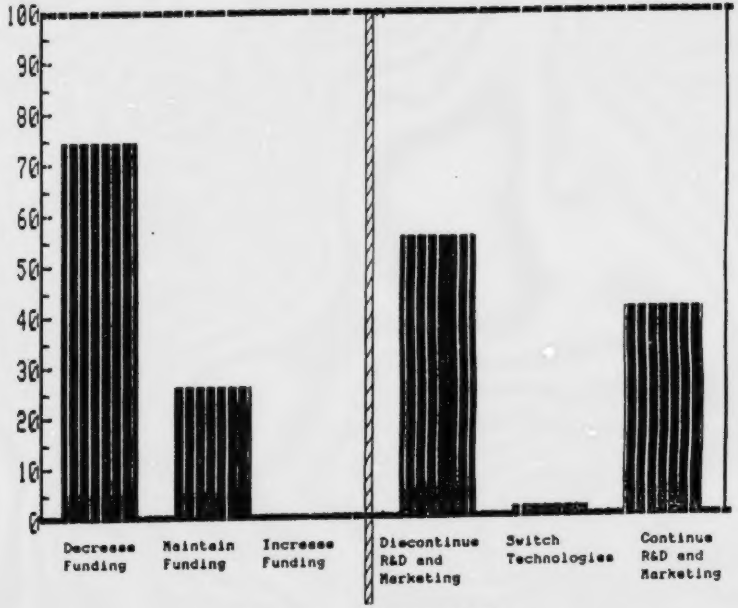
TYPES OF FEDERAL R&D SUPPORT NEEDED

Type of Support	% Yes 1985	%Yes 1981	%Change
Testing prototypes	96	92	+4
Develop subsystems and components	96	89	+7
Full-scale system tests	83	83	+0
Develop conceptual designs	74	62	+12
Basic Research	77	44	+33

Finding 10

INDUSTRY PLANS FOR THE FUTURE

If DOE Funding Discontinued



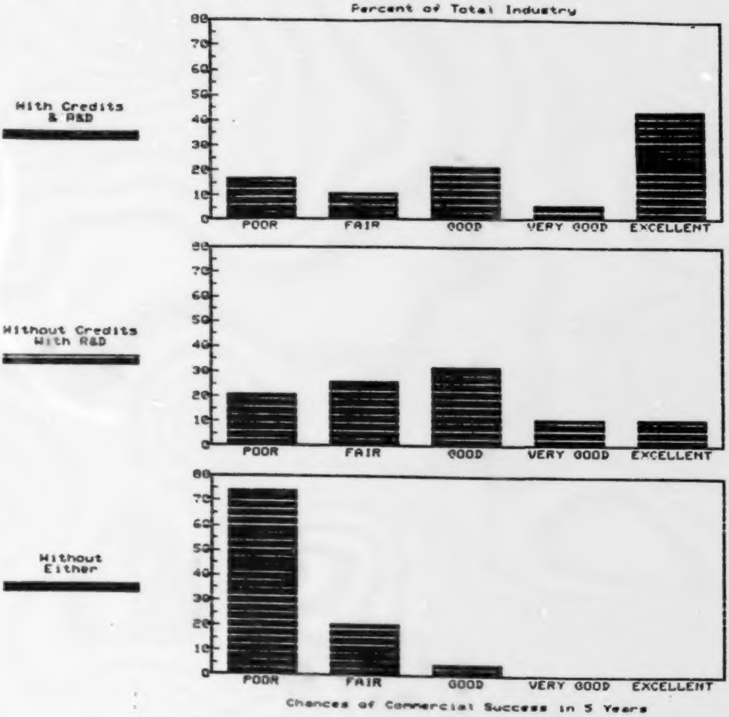
Percent of Respondents

Finding 11

IMPACT OF TAX CREDITS AND FEDERAL R&D

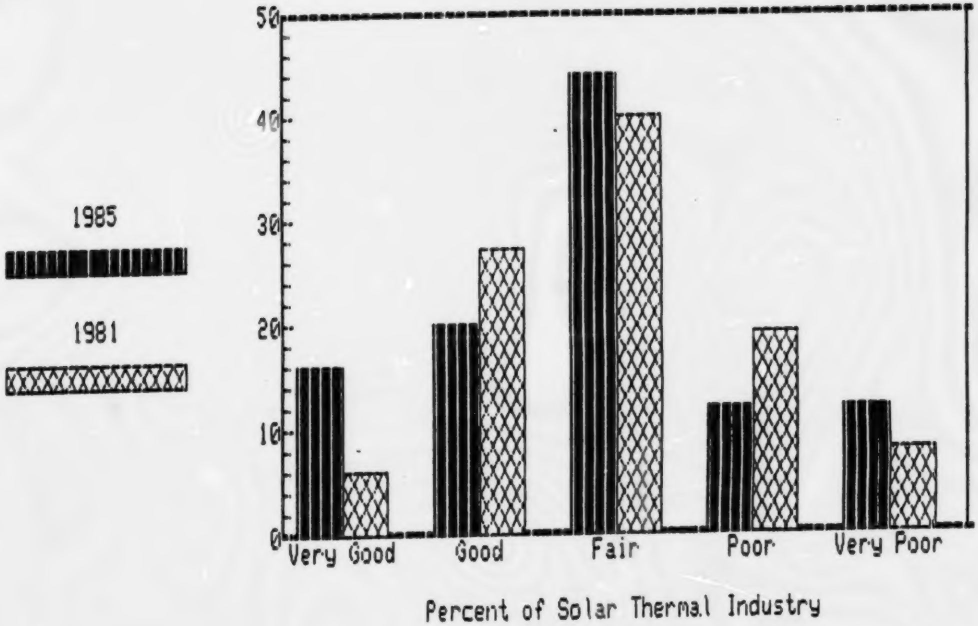
Chances of Commercial Success in 5 Years

Percent of Total Industry



Finding 12

EVALUATION OF THE DOE PROGRAM



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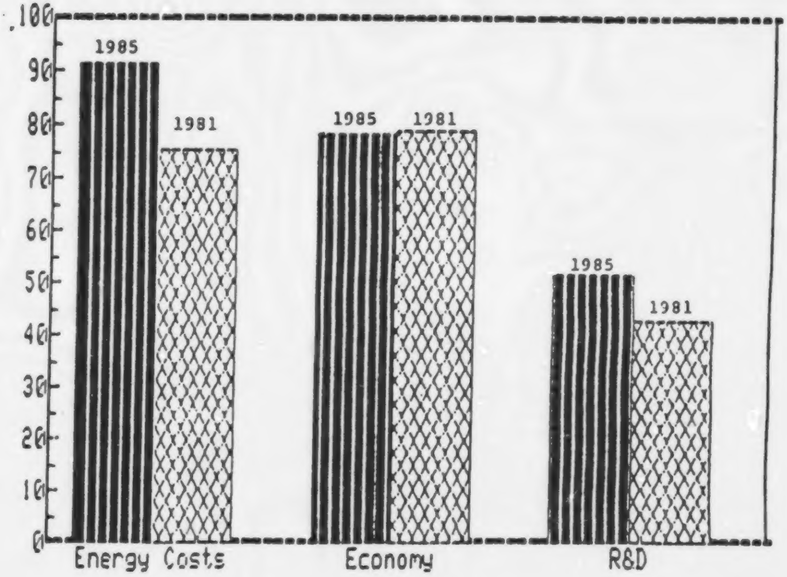
Finding 13

UNCERTAINTIES

Many of the companies stated that their business is more dependent on energy prices than on tax credits and federal support. Most do not expect energy prices to climb significantly within the next 10 years and thus do not expect business to be very good without help in some form. Of the companies that are actively marketing products or services to commercial users, 56 percent (nine companies) expect to make a profit this year and 44 percent (seven companies) do not. Many of the other companies that are not, at present, marketing to commercial users don't expect to make a profit until energy prices rise significantly, whenever that may be. Ninety-one percent of the companies responding to the question (21 companies) believe that the cost of competing energy sources creates an uncertainty for making commercially viable solar thermal products, a significant increase over 1981.



Percent of Industry Identifying Area as an Uncertainty

CONCLUSIONS

- It is clear that the current soft market for oil and gas dominate the environment in which these companies operate.

- There has been a major decline in the solar thermal industry in the last four years.

- The industry expects the decline to continue because no near-term market is in sight and DOE budgets have continued to fall.

- The industry has invested and is willing to continue to invest private funds in solar thermal research and development because it remains optimistic about the potential of these technologies.

- Industry believes that a strong federal role remains essential because of falling energy prices and high technical risks in certain areas.

SOLAREX
Corporation

February 26, 1986

The Honorable Don Fuqua
2269 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

There is significant concern within the United States photovoltaic industry that the proposed 1987 federal budget for photovoltaics is below a credible level to sustain a successful, nationally focused, development program. The $20.6 million dollar effort represents the lowest federal budget for this technology, in terms of real 1975 dollars since 1976. It also represents a lack of understanding and/or interest by the budget formulating officers of the impact that this level of funding will have upon the national photovoltaics effort. Photovoltaics has been shown to be a technology of near and long term strategic importance to the United States and it is in the interest of the government to insure that the focus of this technology stay within the boundaries of the United States. The Japanese, particularly have recognized the value of this resource and would like to gain this leadership. It has been reported that their New Energy Development Organization (NEDO) alone, has planned for a 1987 photovoltaics budget of $35.1 million dollars, 70% more than the US DOE budget.

It may be important to stress here the success realized by the US national photovoltaic effort. In 1973 at the time the present origins of the program were established, photovoltaics for space was the only industry except for a few hundred watts which were produced for terrestrial applications from reject space solar cells. These solar cell modules were sold for greater than $50.00 per watt. In 1985 the sale of photovoltaics is measured in megawatts and prices of less than $6.00/watt are commonly realized. (This is less than $3.00/watt when placed in the context of constant 1973 dollars.) The potential for even lower cost is quite good and the national and international needs and markets for these products are of major importance.

. . . . more

1335 Piccard Drive, Rockville, MD 20850 USA • (301) 948-0202 • TWX 710 828-9709 • TLX 248359 SOLX UR • Cable SOLAREX

Solarex recognizes the important role the US government programs have played in fostering photovoltaic development. Because of DOE support, Solarex has been able to accelerate the development of such new products as its advanced semicrystalline solar cells (a joint program with JPL) and most recently in its thin film solar cells (a joint program with Solar Energy Research Institute). These organizations have been a credit to the national advanced energy development programs. The loss of all or part of these organizations from the U.S. energy development effort is viewed as a loss of a national resource; a resource which will be difficult to replace. As any organization focused into this high tech field of PV recognizes, it takes time and significant effort to assemble the skilled scientists and engineers to make an effective, contributing team. The proposed FY87 budget demonstrates a lack of support for PV and sends a message for the future that will strongly inhibit the attraction of better technical personnel into the federal government's PV operations and laboratories.

It is hoped that this letter will help gain the support of the US Congress to temper the deleterious effects of the proposed FY87 budget. Some tightening of the belt is acceptable but a decimation of the PV program is contrary to the interest of the United States.

Sincerely,

SOLAREX CORPORATION

John V. Goldsmith
Vice President

JVG/ch

BEST COPY AVAILABLE

CHRONAR

February 19, 1986

Congressman Fuqua
2269 Rayburn Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

As you know, Chronar Corp. has been conducting research and development for a number of years in amorphous silicon photovoltaics. In December 1984, Chronar opened this country's first one megawatt manufacturing facility in New York state. We are presently constructing a similar facility in Alabama in a joint venture with the Southern Company. Additionally, Chronar operates a factory in Wales and is constructing facilities which will utilise amorphous silicon technology in France, Yugoslavia and China. The companys work force has grown by a factor of twenty in the past four years. We expect this growth to continue.

The success of Chronar has depended very much upon the company's technology position. The research and development that the company has undertaken during the past ten years has been instrumental in charting new frontiers in this technology.

The cost sharing research and development program that the Department of Energy has been supporting for the past several years has been, in Chronar's opinion, a most successful effort. The company feels strongly however, that this effort must be expanded if American companies are to remain competitive in the world arena. By leveraging the U.S. dollars expended, the United States government can continue to get a most return for its money spent.

In a world which is focusing more and more on amorphous silicon it is essential that the U.S. government renew and expand its commitment. The Japanese government's commitment to amorphous silicon is formidable and well documented. Other governments around the world have increased their involvement in all aspects of research and development in amorphous silicon materials. It is clear that the demonstrated cost reductions during the past few years have sparked a keen worldwide interest in amorphous silicon materials.

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COMMITTEE ON SCIENCE
AND TECHNOLOGY

CHRONAR CORP., P.O. BOX 177
PRINCETON, NEW JERSEY 08540
609 587-8000 TELEX 843394

While we understand that the overall photovoltaic research and development budget is expected to be reduced from FY 1987 from its present level, we feel it is essential that the research and development budget in amorphous silicon be increased.

Chronar would welcome opportunity to present you and your subcommittee with our perspective on the research and development budget for amorphous silicon.

Sincerely,

Richard L. Wright
Executive Vice President

RLW/dst

PGandE's EVALUATION OF WIND GENERATION

Don R. Smith, Consultant, Berkeley, CA
Thomas Hillesland, Jr., Mary Ilyin, William Steeley
Pacific Gas and Electric Company, San Ramon, CA

For Presentation at the 5th ASME Wind Energy Symposium
New Orleans, February 1986

ABSTRACT

One of the goals of the Pacific Gas and Electric Company's (PGandE) Research, Development and Demonstration Program is to identify cost effective alternatives to conventional electric generation. Evaluation shows that wind energy systems are becoming an attractive option for future generation.

The objectives of PGandE's Wind Energy Development Program include:

1) identifying and quantifying the resource,
2) gaining hands-on experience in selecting, siting, operating, and maintaining a large wind turbine, and
3) evaluating privately owned wind farms.

In this paper the performance of the PGandE MOD-2 wind turbine will be discussed, as well as that of the privately owned wind farms in Altamont Pass.

INTRODUCTION

The Pacific Gas and Electric Company (PGandE) is in an excellent position to evaluate wind energy. The company owns and operates one of the world's largest wind turbines, the MOD-2 in Solano County. This turbine is presently second only to the WTS-3 turbine in Sweden in total kilowatt-hours (kWh) of electricity produced by a single turbine.

Although PGandE does not own the Altamont Pass wind turbines, which together form the world's largest wind generating plant, the Company purchases their output. At the time of writing, November 1985, it appears that the Altamont Pass wind farms will produce about 375 million kilowatt-hours during 1985. This corresponds to the residential needs of a city with a population of about 130,000, and will amount to about six-tenths of a percent of PGandE's 1985 electrical sales. During windy evenings the Altamont Pass turbines often produce over two percent of PGandE's electrical power.

PGandE keeps track of the numbers and types of turbines on each farm, and is being allowed by developers to monitor four different types of turbines. Wind data is being collected at three sites. In this way the Company is evaluating the performance of the Altamont mid-sized turbines to assist it in considering the possible future purchase of wind generating facilities.

THE PGandE MOD-2 WIND TURBINE

In 1981 PGandE selected a site for installation of its first wind turbine. The site is in Solano County, California approximately 50 km (30 miles) northeast of San Francisco. The site had a mean wind speed of 8.3 m/s (18.6 mph) at a 9 meter height (30 ft.) based on wind data taken over a 10 month period.(1)

After competitive bidding, PGandE purchased a 2,500 kW wind turbine from Boeing Aerospace Company (BAC) in 1982. This MOD-2 wind turbine has an upwind 92 meter (300 ft.) diameter rotor, a teetered hub, a "soft" tower, and blade tip pitch control. PGandE's unit began operation in April 1982 and has produced more than 8,600,000 kilowatt-hours in over 5,500 hours of operation as of November 1985.

ALTAMONT WIND PLANT EVALUATION

In 1984 PGandE began evaluating the privately owned Altamont Pass wind farms as a composite wind power plant. These wind farms have been developed due to favorable state and federal tax incentives, and the Altamont Pass area now has the largest collection of wind driven electrical generators in the world.

By the end of 1985, about 5500 machines will have been installed having a combined rating of about 520 megawatts. However, since there is no standard wind speed for rating turbines, manufacturer's ratings are not uniform, and can't be directly compared. This will be discussed later.

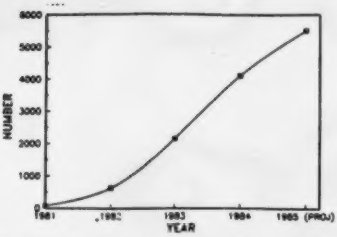
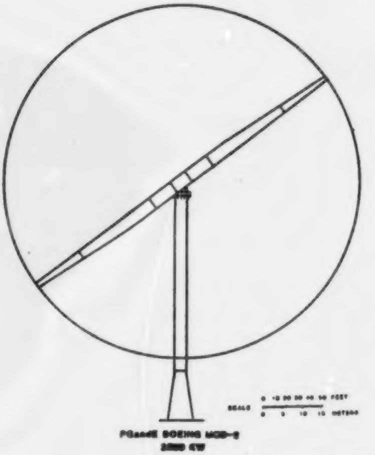


Fig. 1 Total number of wind turbines in Altamont Pass

Figure 1 shows the number of turbines in Altamont Pass during the last few years. The rate of increase appears to be leveling off. About 1400 were installed in 1985, compared to about 2200 in 1984. Since first going into operation in late 1981 until November 1985 these wind farms have produced and sold to PGandE over 500 million kilowatt-hours of electricity.

At least 17 different types of horizontal axis turbines and two sizes of vertical axis turbines are installed. Figure 2 shows line drawings of the Altamont Pass turbines and the PGandE MOD-2 all drawn to the same scale.


SCALE
0 10 20 30 40 50 FEET
0 5 10 15 METERS
PGandE BOEING MOD-2
2500 KW

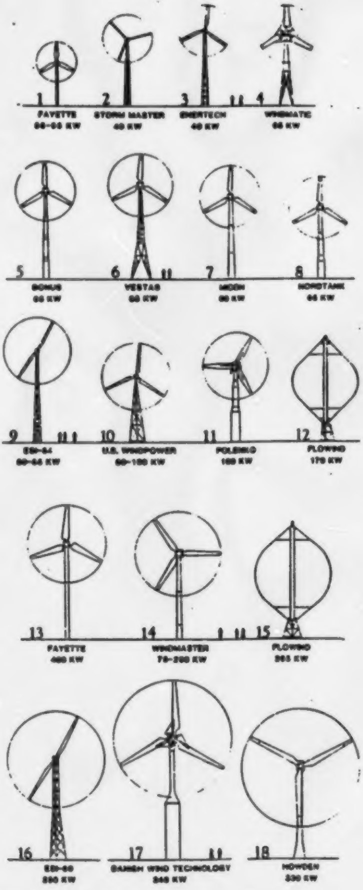

1
FAYETTE
2
STORM MASTER
40 KW
3
ENERTECH
40 KW
4
WINDMATIC
65 KW
5
BONUS
65 KW
6
VESTAS
65 KW
7
MICON
60 KW
8
NORDTANK
65 KW
9
ESI-54
50-65 KW
10
U.S. WINDPOWER
50-100 KW
11
POLENKO
100 KW
12
FLOWIND
170 KW
13
FAYETTE
400 KW
14
WINDMASTER
75-200 KW
15
FLOWIND
265 KW
16
ESI-80
250 KW
17
DANISH WIND TECHNOLOGY
240 KW
18
HOWDEN
330 KW

Fig. 2 Altamont Pass and MOD-2 wind turbines all drawn to the same scale

The power ratings of the Altamont Pass turbines range from 40 to 400 kW, and the rotor diameters vary from 10 to 31 meters (34 to 103 feet). The average rating of the new turbines installed each year has increased annually as shown in Figure 3.

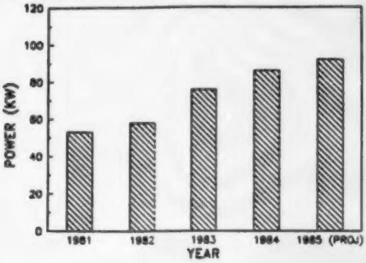


Fig. 3 Altamont Pass wind turbine average rating

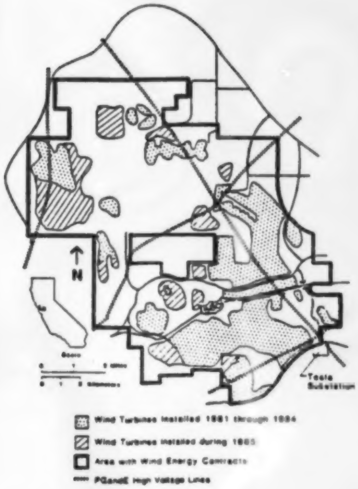

N
Scale
0 1 2 Miles
0 1 2 Kilometers
Tesla Substation
Wind Turbines Installed 1981 through 1984
Wind Turbines Installed during 1985
Area with Wind Energy Contracts
PGandE High Voltage Lines

Fig. 4 Altamont Pass map

The Altamont Pass wind farms are located about 70 km (45 miles) east of San Francisco, California. By January 1986 about 60 sq. kilometers (23 sq. miles) will have been developed with an average of one wind turbine for each 1.2 hectares (3 acres) of land. This amounts to about 8.6 MW per sq. kilometer (22 MW per sq. mile). Figure 4 is a map showing the areas developed as of September 1985. Also shown are the PGandE high voltage lines serving the wind farms.

MOD-2 PERFORMANCE

The Electric Power Research Institute (EPRI) co-funded with PGandE a two year evaluation of the MOD-2 performance. During the first few years the wind turbine operated at a low availability due to outages caused by a number of problems. The turbine's pitch control system was initially unstable at rated power. Several control procedure revisions and other changes by BAC were necessary before routine reliable operation was obtained (2).

Other areas which required modification or repair included the yaw drive, the tower, the low speed shaft, various sensors, the low speed shaft bearing seals and lubrication system. Some outages were caused by external utility problems such as line outages and the line voltage being out of range for the wind turbine's voltage regulator.

In 1983 BAC added vortex generators to the midsection of the rotor. The vortex generators have the potential to increase annual energy production about 14% based on the measured performance improvement and the wind resource.

MOD-2 Capacity Factor

A common measure of power plant performance is the capacity factor, which is the average power over a given time period divided by the rated power. For a conventional steam power plant a typical annual capacity factor might be 0.70.

Due to the nature of wind distribution, an annual capacity factor of 0.25 to 0.35 is considered a typical goal for a wind turbine. The MOD-2 wind turbine now has the potential of achieving an annual capacity factor of 0.29 to 0.35 if it operates at a high availability. The MOD-2 wind turbine's annual capacity factors are shown in Figure 5. The annual capacity

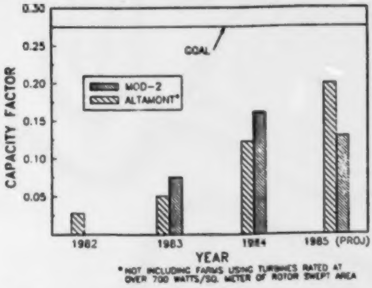


Fig. 5 MOD-2 and Altamont wind turbine capacity factor

factor improved annually, except in 1985. The decrease in capacity factor in 1985 is because the MOD-2 wind turbine was not operating during most of June and part of July and August. Scheduled and unscheduled maintenance were performed during this time. The unscheduled maintenance included the installation of the bearing lubrication system, repair of a low speed shaft crack and a control card revision.

How close has the MOD-2 come to attaining its potential and what are the reasons for the shortfall? Its performance in 1984 was analysed. Based on the wind distribution measured at the site, and considering that it was turned off 8% of the time for scheduled maintenance, it could have attained a capacity factor of 0.33. But its actual capacity factor was 0.16, or 49% of the maximum attainable capacity factor. Figure 6 shows the actual output as a proportion of the potential output.

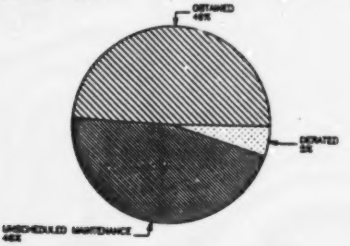


Fig. 6 MOD-2 potential and actual energy in 1984

MOD-2 Availability and Rating

The main source of the lost potential output was because the turbine was shut down for unscheduled maintenance during times when half of the potential 1984 wind energy occurred, as shown in Figure 6. Reasons for the shut downs included problems with controls and back up systems, and oil leaks.

During part of the year the turbine was derated to 2,200 kW due to stability problems. Examination of the wind distribution during this period indicates that the lower rating resulted in lost energy representing about 5% of the potential annual output.

ALTAMONT PERFORMANCE

The capacity factor, the most common method of measuring the performance of power plants, is less appropriate for use with wind power plants than other plants. This is because wind turbines are rated at varying wind speeds, depending on the expected wind distribution and the design philosophy of the maker.

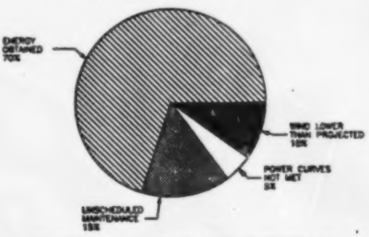
Most of the Altamont wind farms use turbines having a rated power of 300 to 700 watts per square meter of the area swept by the rotor (28 to 65 watts per square foot). This generally results in a turbine that attains its rated power only in wind speeds above 12 to 16 m/s (27 to 34 mph). There are a few types of turbines in Altamont Pass raced at from 900 to 1200 watts per square meter (84 to 112 watts per square foot), resulting in rated wind speeds over 18 m/s (40 mph). It is not valid to compare or combine the capacity factors of these turbines with those rated at more typical wind speeds.

There have been attempts to develop more appropriate turbine performance evaluation tools, such as rating all turbines at a standard wind speed or output measures based on rotor area rather than generator rating. However, the capacity factor remains widely used, and is well understood by those familiar with conventional power plants. Hereafter in this paper, we will consider only the farms using turbines rated at less than 700 watts per square meter (65 watts per square foot) which represent 88 percent of the rotor swept area in Altamont Pass.

Altamont Capacity Factors

Based on projections made in November 1985, the 1985 capacity factors for the farms under consideration will range from 0.13 to 0.25, with 0.19 being the overall figure. This compares with a capacity factor for these farms of 0.03 in 1982, 0.05 in 1983, and 0.12 in 1984. This impressive performance improvement was shown in Figure 5.

How does this capacity factor compare with the projections made by the developers? The wind farm prospectuses have been examined and they project annual capacity factors of from 0.20 to 0.34, with 0.27 being the weighted average for the farms considered here. Thus the 1985 achieved capacity factor of 0.19 will be 70% of the wind farm projections. See Figure 7.



*INCLUDING ALL FARMS EXCEPT THOSE USING TURBINES RATED OVER 700 W/SQ. METER ROTOR SWEPT AREA

Fig. 7 Altamont Pass 1985 projected and actual energy

This is excellent performance for an emerging technology. Can the performance be expected to continue to improve? To examine this question we must estimate the sources of the 30% deficit in 1985 output. We think that the major causes of the shortfall were:

1) lower than expected turbine availability,
2) the wind not meeting projections, and
3) turbines not meeting their power curves.

These three factors will now be considered.

Although most developers do not explain the exact method they used to arrive at their annual output projections, in general they appear to have arrived at their capacity factors by applying a measured Altamont wind distribution to the power curves for their turbines, and then subtracting various losses. The distributions used (often from the C.E.C./PGandE 1980 study) have mean wind speeds of 7 to 8 m/s (16 to 18 mph) representing the winds on exposed ridgelines (3).

The projected annual output found by simply applying the annual wind distribution at a very good site to the power curve of a turbine is higher than can actually be obtained. The developers point out sources of losses in the prospectuses. For this paper we will assume the losses are 6% due to machines not being available, 5% for electric losses on the farm, and 7% for the wind actually acting on the turbines not being as good as that seen on a few isolated hill tops before turbines were installed. These figures are chosen to be near the average of those given for those developers who gave this information, and they appear reasonable. This method results in the projected output being 0.94 x 0.95 x 0.93 or 0.83 of that found from the distribution and power curves. This approach results in projected annual outputs very close to those given by most of the developers, including those who give little or no information as to how they arrived at their projected annual outputs.

Altamont Wind Turbine Availability

Based on spot checks, developer information, and monitoring programs, including ours, it appears that typically about 20% of the turbines installed on these farms were not available to generate during 1985 (4). On the average, the developers assumed that their turbines would be available about 94% of the time. The actual availability of about 80% would result in an annual output only 80/94 or about 85% of what was expected. Thus about 15% of the projected 1985 output was lost due to turbines being down while awaiting repair for unexpected problems, or entire farms being not operated for various reasons. This is shown as unscheduled maintenance on Figure 7.

Several farms have attained turbine availabilities of 95% during the year, while others have lost up to 30% of their 1985 potential output due to turbines being shut off. These were usually earlier models being repaired or retrofitted. Problems that have resulted in turbines being shut down include inadequate pitch control mechanisms and blade spars, failures of mechanical brakes and improper activation of tip plate aerodynamic brakes, tower cracks, foundation problems, generator failures, and inadequate wiring. Some of these are shown on Figure 8. Most of these problems appear to be solved or solvable. Less than one percent of the wind turbines in Altamont Pass lost blades or suffered other catastrophic failures during 1985.

Examination of the hourly outputs of the farms during July 1985 showed that during about 5% of the time when the wind speed was well above cut-in, the typical farm produced no output. This was probably due in most cases to substation or other electrical problems.

Power Curves Not Attained

Another source of the 1985 Altamont output shortfall was turbines not meeting their projected power curves. Almost all of the turbines meet their claimed power curves in low winds, some level off at a lower than projected maximum power below the rated wind speed. This is also true for some turbines with fixed pitch blades which lose significant power when their blades are soiled by insect build up.

Another source of energy loss related to power curves happens during high winds when occasional gusts above the cut out wind speed, which is usually from 20 to 27 m/s (44 to 60 mph) on the Altamont turbines, keeps the turbines shut down even though the average wind speed indicates that output should be at rated during the period. Control algorithms are being developed to minimize these losses.

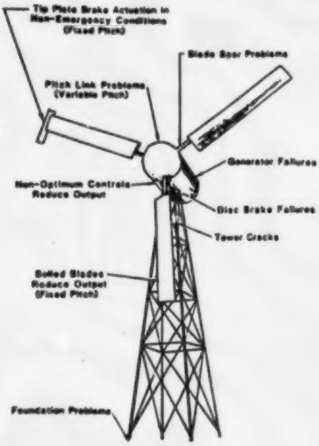

Tip Plate Brake Actuation in Non-Emergency Conditions (Fixed Pitch)
Blade Spar Problems
Pitch Link Problems (Variable Pitch)
Generator Failures
Non-Optimum Controls Reduce Output
Disc Brake Failures
Tower Cracks
Soiled Blades Reduce Output (Fixed Pitch)
Foundation Problems

Fig. 8 Altamont Pass wind turbine problems

Comparing the output based on actual and predicted power curves with wind distributions in Altamont Pass indicates that some turbines may lose up to 10% of their potential annual output because of not meeting their projected power curves. Overall, it appears that the failure of many turbines to met their projected power curves resulted in about 5% of the projected 1985 output not being obtained. This is shown in Figure 7.

Most of these losses can probably be eliminated by alteration of blade pitch angles, different rotor speeds, different airfoil profiles and/or the use of vortex generators on blades, and the fine tuning of operating algorithms. Some of these changes can be made on machines in the field, while others could be included in future production units.

Estimating Wind Speeds from 1985 Wind Farm Output

We assume that the remaining major cause of the 1985 Altamont Wind Plant output being less than projected was lower than expected wind speeds. Several developers say this was the case. It is possible to make a rough estimate of the wind distribution experienced by a wind turbine from its output, in effect using the turbine as an anemometer. Using this approach the wind distribution seen by the average turbine can be approximated.

As mentioned before, the wind farms under consideration will have a 1985 capacity factor of 0.19. The capacity factor that would have been expected from this group of turbines was computed by us from two different annual Altamont wind distributions, one with a mean wind speed of 7.4 m/s (16.6 mph) and the other with a 5.4 m/s (12 mph) mean. These capacity factors are based on our estimated turbine power curve deficit being 5% of the annual potential output, 5% on-farm electrical losses, and the 80% availability estimated before. The distribution with the higher mean wind speed gave a projected capacity factor of 0.20, while the other gave 0.13. By interpolating between the two numbers, it can be estimated that the average turbine under consideration saw a wind distribution with a mean wind speed of about 7 m/s (16 mph). This is about 0.5 m/s (1 mph) less than the mean annual wind speed assumed by most developers. This wind deficit corresponds to about 10% less annual energy.

Considering each wind farm in the same way it was estimated from their 1985 outputs that the approximate average wind speed seen by the turbines on different farms varied from about 6.5 to 8 m/s (14 to 17.5 mph).

Reasons for Lower than Expected Winds

This lower than projected wind distribution may be due to a combination of three elements. First of all, the general wind distribution in Altamont Pass may not be as strong as originally estimated from meteorological towers on selected, well exposed hills. A related element may be the variation from year to year of the average Altamont Pass wind speeds, although determining whether 1985 was a low, high, or average wind year is difficult.

A second reason the typical turbine was apparently exposed to lower than projected wind speeds may have been poor micro-siting. It is now understood that in the complex terrain of Altamont Pass the wind varies greatly over short distances. Two wind farms moved significant numbers of turbines during 1985 to sites determined to have better wind.

A third reason the typical wind turbine experienced lower winds than predicted from the meteorological studies done before any turbines were installed is array effects. Turbines must slow the wind down in extracting energy from it, leaving less energy in their wake for turbines downwind. This may be especially significant in the eastern part of Altamont Pass, where the flatter land allows turbines to be installed in tight grids spaced from eight to ten rotor diameters apart along the prevailing wind direction. Studies have estimated that at this spacing array effects may reduce the annual output about 10 percent, roughly corresponding to the average turbine seeing winds about 0.5 m/s (1 mph) less than it would if the other turbines weren't there.(5) Thus array effects may explain most of the apparent wind deficit on some of the farms. This phenomenon is being studied by PGandE and others.

POWER CURVES

As reported before, the MOD-2 meets its claimed power curve after the installation of vortex generators on the blades.(6)

Shown in Figure 9 is a power curve based on the output of all the Altamont Pass turbines under consideration and the wind from two sites in Altamont Pass during July 1985. It was created by a method similar to that developed by Southern California Edison.(7) However, this power curve is based on an average windspeed from two sites, as this produced less scatter of the data than using the wind from just one site.

Also shown is the output projected from the wind and the manufacturer power curves of the turbines in operation. This was done by the authors using the method developed in an earlier paper.(8) The difference between the projected and actual average power presumably represents turbines not available or not meeting their projected power curves. However, the scatter of the plot (the dotted lines are a 90% confidence interval) may be more due to wind variation in the Pass than to turbines not being in operation. Another problem in analysing this curve is that the number of turbines in the Pass was increasing during the month.

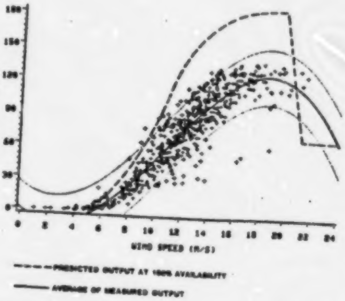


Fig. 9 Altamont Pass projected and actual power curves not including turbines with over 700 watts/sq.m

OUTPUT PREDICTION

It would be of value to a utility for dispatching if it were possible to predict wind turbine output a day or even an hour early. We have run correlations between high and low temperatures at San Francisco, Livermore (west of Altamont Pass) and Tracy (east of the Pass) and the Altamont Pass winds and wind farm output the next afternoon. No clear connections have been found that would allow wind prediction.

However, preliminary examination of daily wind patterns show that in July 1985, with the exception of one day, if the Altamont was producing significant power at 3:30 pm, it was producing even more at 4:30. Similarly, an examination of the winds at a site in Altamont Pass during June through August of 1985 found that, for 95% of the afternoons, if the wind was strong at 2:00 pm it was stronger at 4:00 pm, when PGandE's load is usually at its daily peak. This might be of value to utility dispatchers.

OPERATIONS AND MAINTENANCE COSTS

The MOD-2 wind turbine has not operated a sufficient amount of time to derive mature operation and maintenance (O&M) costs. The reliability of the machine increased between 1982 and 1984 but there are still frequent failures. The mean time between failures is about 50 hours. Excluding major repairs, depot and control stations costs and maintenance equipment, the single unit annual operation and maintenance (O&M) costs, would be approximately $47,900 for a typical operating year. This information is based upon a R. Lynette and Associates study performed for EPRI.(9) This annual cost spread over the 3,536,000 kWh produced in 1984 results in an O&M cost of $0.014 per kWh.

R. Lynette and Associates is also monitoring several wind farms, including five in the Altamont Pass Area, and recently estimated that operations and maintenance costs will stabilize at $0.007 to $0.011 per kWh.(10)

We have also estimated the operations and maintenance costs of the Altamont Pass wind farms in two other ways, both of which result in figures close to Lynette's. Based on what several turbine manufacturers charge for O&M contracts and comparing this to 1985 output results in an annual cost of about $0.01 per kWh. Considering the number of maintenance employees at some Altamont wind farms and estimating labor and parts costs also results in a cost of about $0.01 per kWh.

One implication of these reasonable O&M costs is that, regardless of what happens with tax credits, those farms already built in Altamont Pass should be able, based on their O&M costs, to continue to operate for the foreseeable future, as these costs are considerably less than the price paid by PGandE per kWh produced.

COST OF WIND ENERGY

The three major factors in computing the cost of evergy for a wind power plant are the total cost of the wind farm (including roads, wiring, etc., in addition to the turbines), the operations and maintenance costs, and the annual output.

The MOD-2 is a research project, and future similar production units, if built, should be much less expensive. It cost about $10,000,000, but the cost of roads, substation, etc. would be much less per turbine in a wind farm. The total PGandE MOD-2 project cost $4,000 per kW. Using a fixed charge rate of .098, which assumes a thirty year life and factors out inflation, and an O&M cost of $0.014 per kWh, and using the 1984 capacity factor of 0.16 results in a cost of energy of about $0.29 per kWh.

This cost is not competitive, but the MOD-2 has demonstrated the potential to come close to its output projections with reasonable maintenance. If the tubine and balance of plant costs could be reduced by more than half, and the production could be improved to the expected level, it might compare in economics to the smaller mass-produced turbines in Altamont Pass.

The average cost to the investor of the Altamont Pass wind farms under consideration has been $1900 per installed kW. Using the same fixed charge rate as above, an O&M estimate of of $0.015 per kWh, and the 1985 capacity factor of 0.19 results in a cost of energy of about $0.13 per kWh. Note that this estimate does not consider that the net cost to the investor is much less than $1900/kW due to state and federal tax benefits, nor does it reflect the fact that the cost per kW of the Altamont turbines has been coming down.

It should also be pointed out that the developer partnerships are complicated by various fees which depend on production and change over time, stock options, loans from the developers and other factors. The partnerships also include substantial brokerage and legal fees.

We would estimate that a wind farm could be built using available wind turbines in Altamont Pass for $1200/kW which could attain an annual capacity factor of 0.27 if properly sited. This would result in a cost of energy of $0.06 (factoring out inflation) which is less than PGandE pays the wind farms for their energy today. It is also possible that cost reductions in turbines would make the cost of energy even more competitive.

FUTURE ACTIVITIES

In the future PGandE will continue to evaluate its Solano Wind Turbine and the Altamont Wind Power Plant. Additional detailed wind resource studies are underway on PGandE's own sites. A study of wind turbine array effects at a co-operating wind farm has been initiated. Also in progress is a conceptual wind power plant design by PGandE's Engineering Department for a site owned by the Company.

ACKNOWLEDGMENTS

We would like to thank Steve Holets and Bob Swanson of the PGandE meteorology department and Lamar Parker for their assistance in gathering and analyzing wind data, Ed Betz for his help in analyzing wind farm output data and comparing it with wind data, and Sue Grubb, Laraine Chaney, Ted Parker and Ben Morris for producing the figures.

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(2) Tom Hillesland and William Steeley, MOD-2 Wind Turbine Field Experience in Solano County, California, PGandE, prepared for EPRI, September 1985.
(3) Earl Davis and Ron Nierenberg, Wind Energy Prospecting in Alameda and Solano Counties, PGandE, San Francisco, May 1980.
(4) See ref. 2 above.
(5) P.B.S. Lissaman, Presentation to California Wind Energy Association Annual Conference, May 15, 1985, Pasadena.
(6) Jay Stock, "Integrating Wind Energy into the Electric Utility System", WINDPOWER '85, San Francisco, August 29, 1985.
(7) Don R. Smith, William Steeley, and Thomas Hillesland, "Status of the 220 Megawatt Altamont Wind Power Plant", Fourth ASME Wind Energy Symposium, Dallas, February 17-21, 1985.
(8) Don R. Smith, William Steeley, Thomas Hillesland, Mary Ilyin, Pacific Gas and Electric Company's Wind Energy Program Results WINDPOWER '85, San Francisco, August 29, 1985.
(9) See ref. 2 above.
(10) R. Lynette, Wind Power Stations: 1985 Performance and Relibility EPRI.

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Georgia Institute of Technology
Office of Vice President for Research
Centennial Research Building
400 Tenth Street, N.W.
Atlanta, Georgia 30332

March 28, 1985

Dr. Harlan Watson
Science Consultant
House Subcommitte on Energy Development and Applications
House Committee on Science and Technology
Rm B-374 Rayburn House Office Bldg.
Washington, D.C. 20515

Dear Harlan:

If the hearing record on the Department of Energy programs is still open, I would like the enclosed testimony from Georgia Tech to be considered for inclusion. There are two pieces of testimony: one covering biomass and the other solar thermal. The biomass submission focuses on a Georgia Tech process that has recieved very favorable technical reviews.

The solar thermal testimony supports university research efforts and continuing a solar thermal effort in general.

I appreciate your interest in these issues and the support the Subcommittee has given to these areas of research. Please let me know iff I can ever be of assistance to you.

Sincerely,

Patty Bartlett

Patty Bartlett

An Equal Education and Employment Opportunity Institution

A Unit of the University System of Georgia

TESTIMONY FOR HOUSE SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

March, 1986

SOLAR THERMAL TECHNOLOGY

H. O. Spauschus, Ph.D and D. J. O'Neil, Ph.D
Energy and Materials Sciences Laboratory
Georgia Tech Research Institute
Georgia Institute of Technology
Atlanta, Georgia 30332

It is the firm belief of the Georgia Institute of Technology that a further erosion of the USDOE solar thermal budget from an average $30M for the last two years to a proposed $15.3M for FY'87 will:

(1) decimate the already-depleted university research programs

(2) isolate "research" activities in one center (SERI) and "engineering" development activities in only one other center (SANDIA, Albuquerque)

(3) dismantle and disperse core teams of veteran solar researchers and technologists

(4) eliminate the training and education of students in preparation for an emerging technology and industry

(5) drive committed U.S. researchers and industrial technology to seek foreign research and commercial development support

(6) surrender previously-funded market and technology leads to foreign competitors.

In 1971, long before the first mideast oil embargo, Georgia Tech researchers became the first U.S. scientific team to conduct experiments at the world's largest solar furnace. By 1977, the Advanced Components Test Facility was built on our campus and has been continually operated on behalf of the U.S. Department of Energy. We have been intimately involved at all stages of the development of solar thermal technology with private industry, university and government laboratories as well as with an international community. We have seen the development of solar thermal technology rapidly climb towards the system - level targets for the mid-to-late 1990's of $0.5/k Whe (electricity) and $9/MBtu (Heat). In addition to Solar Thermal Power Industry, a new cadre of companies, much more broadly based and drawn from aerospace (including space commercialization interests), advanced materials, and the specialty chemical industry, are beginning to be attracted by the prospects of solar-unique products and processes using solar thermal technology. To reduce research funding at this stage is to eliminate this new, emerging industrial interest.

Georgia Tech urges the continuation of funding at current levels of approximately $30M and adherence to a consistent multi-year research plan as outlined in the September, 1985 plan of the USDOE Solar Thermal Technology Division. We particularly endorse the following recommendation of the "Report of the Solar Panel of the Energy Research Advisory Board to the United States Department of Energy, December, 1985 (DOE/S-0039):

"Reasonable diversity in laboratory participation in research, along with continuation or even increases in the base of university and industry research activities, must be maintained to provide adequate opportunity for collaboration, competition, creativity and technology transfer and yet assure an efficient and effective use of limited resources.

TESTIMONY FOR HOUSE SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

March, 1986

BIOFUELS ENERGY SYSTEMS

D. J. O'Neil, PhD and H. O. Spauschus, PhD
Energy and Materials Sciences Laboratory
Georgia Tech Research Institute
Georgia Institute of Technology
Atlanta, Georgia 30332

The Georgia Institute of Technology has been an established leader in bioenergy and biomass conversion research and development since well before the 1970 oil crises. It is, and has been, intimately involved with virtually every aspect modern biomass technology development (alcohol fuels, pyrolysis, gasification, anaerobic digestion, etc.) with private industry, university and government laboratories, and with the international community.

GIT view with great concern the continued erosion of federal funding for USDOE's Biofuels Energy Systems. It views the proposed FY,87 level of $12.2M, a reduction from a previous low in FY,86 of $27.3M, to be indefensible and grossly shortsighted.

GIT urges that the proposed budget be rejected and endorses a return to a funding level which, as a minimum, equates with FY'86 levels, a level which it considers to be already reflective of and responsive to the national economic constraints. Furthermore, it urges a redistribution in research allocations to enhance support of university-based research.

The distribution of funds to the research community, particularly the university research community, in the field of biofuels energy research has been travesty worthy of comparison to the trickle-down effects of misplaced foreign aid. For example, of an apparent FY'86 budgeted line item of $11,500,000 for "thermochemical conversion" research, as of this month only $2,400,000 is reportedly expected to be released for support of university researchers . This situation is as dramatic an examples of the conditions which led to the disproportionate reduction in support of university research as recently cited by The Solar Panel of the Energy Research Advisory Board to the United States Department of Energy (Report DOE/S-0039, December 1985) and which led to the recommendation:

> "Reasonable diversity in laboratory participation in research, along with continuation or even increases in the base of university and industry research activities, must be maintained ---"

To meet that recommendation funding will have to be maintained, university participation will have to be more directly managed form one central coordinating source, large money-gobbling demonstration projects will have to be deferred or conducted, as effectively shown, through Regional Biomass Programs and their cost-sharing approaches.

We concur with the Energy Research Advisory Board that USDOE's civilian R & D programs, which include both basic sciences and energy technology, are long-term investments which must be protected and supported to provide the Nation with the ability to deal with an uncertain energy future.

Goal-directed programs, such as the development of entrained pyrolysis process for petroleum substitution, must be keep immune from short-term swings in oil supply and demand. As the ERAB report states. "First, essentially all projections of future energy markets, including those of DOE, indicate that by the year 2000 there will be substantial increases in petroleum imports and significant real escalation in prices'. (Report DOE/S-=0046, December 1985).

1987 DEPARTMENT OF ENERGY AUTHORIZATION

THURSDAY, MARCH 6, 1986

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 10 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Mr. Fuqua. The subcommittee will be in order. Today we conclude the subcommittee's hearings on the Department of Energy's fiscal year 1987 authorization request, and we welcome witnesses from a wide and interesting variety of organizations to discuss the conservation budget.

In earlier hearings we've reviewed similar circumstances to those we find in the conservation budget. First, there's a significant reduction in funding below the fiscal year 1986 appropriation level, in this case nearly 60 percent; second, DOE has advised us that they plan to defer a significant amount of funding from fiscal year 1986 to support the programs remaining in fiscal year 1987; and third, we're also advised that DOE has taken action with a number of contractors on the basis that the deferrals will be acceptable to the Congress. Well, these program reductions and deferrals are even greater in magnitude for the total Energy Conservation Program in which we share jurisdiction with other committees.

The concern that continues to rise is that these substantial reductions in annual funding will not allow DOE to attain presently existing long-term program objectives and goals. These appearances of saving money mask the effect of wasting money spent in prior years through failure to accomplish project and program missions. If similar program reductions can be expected to make lower deficit ceilings in subsequent years, it will not take long to eliminate all the programs totally.

We have requested that several of our witnesses comment on budget levels at a reduction of 15 percent from the fiscal year 1986 appropriation levels. And their suggestions and recommendations will be very beneficial to the subcommittee as it tries to establish an alternative to the fiscal year 1987 conservation budget.

And I'd like to recognize Mr. Sensenbrenner for any comments that he wishes to make.

Mr. Sensenbrenner. Thank you very much. Mr. Chairman, due to time constraints, not everyone who wanted to testify today will be able to do so. One such group is the Petroleum Marketers Association of America. I'd like to ask unanimous consent that a written statement be included in the hearing record from the PMAA regarding their concern over the proposed lack of funding for oil heat research and development in DOE's fiscal year 1987 budget request. This organization represents 11,000 independent marketers of petroleum products, equipment, and service.

I'd like to point out that the draft was revised and was just handed to me. I did review the first draft of it, but I have not reviewed this one. But I would like to have it included in the record.

Mr. FUQUA. Without objection we'll make it a part of the record.

[Statement of Petroleum Marketers Association of America appears as additional statement for the record.]

[Additional remarks of Hon. William Cobey follow:]

I would just like to add that my state of North Carolina is a large user of home heating oil. R&D research in this area would increase conservation options and would be environmentally beneficial in many ways. Oil heat R&D is important to our future energy needs, and I agree with my colleague from Wisconsin of the need to support increased funding in this area. Thank you.

Mr. FUQUA. Our first panel will be Dr. Mary L. Good, president of Signal Research Center, followed by Dr. James H. Leonard, vice president of technology of Bethlehem Steel, and Mr. Robert C. Howard of Thermo Electron Corp. If they would please come forward.

Dr. Good, we're especially pleased to have you back once again and congratulate you on your recent elevation to the post of president of the American Chemical Society, a very distinguished and prestigious group. And we'll be pleased to hear from you at this time.

STATEMENT OF DR. MARY L. GOOD, PRESIDENT, SIGNAL RESEARCH CENTER

Dr. GOOD. Thank you very much, sir. I really appreciate the opportunity to be here today, and I thank you for the time on the agenda because I really do have some comments on, particularly, the conservation program, and, I think, there are really things that we need to discuss.

I have written testimony which is available, and I'm going to just excerpt some of that if I may, and then I'd be willing to try to address any questions that you might have, Mr. Chairman.

Mr. FUQUA. I might say, too, that we are under the constraints not only of trying to get the hearings through so that we can start markup because of an accelerated schedule—and we have been trying to encourage the witnesses to try to limit their remarks to 10 minutes or less.

Dr. GOOD. Fine.

Mr. FUQUA. And so, we would appreciate that for all our witnesses today. Thank you very much.

Dr. GOOD. Very good. I'd be happy to do that. What I'm going to do is just to look in detail at the interdisciplinary research programs that are in ECUT. I have in the back of my testimony an appendix which gives at least a very brief review of each of those.

Now, the four areas are in materials, biocatalysis, tribology, and combustion and thermal sciences. Now, the underlying concept upon which that entire effort is based is called materials-by-design. The concept involves the development of research tools to accelerate the Nation's capacity to innovate. I would like to use materials-by-design to illustrate the value of ECUT's programs.

It is a generic approach to solving technology problems that can be applied to all of the other ECUT programs. Materials-by-design is a new way of doing science that promises radically new and vastly superior materials; stronger, lighter, more energy efficient, and less expensive than anything known today.

Such breakthroughs will be possible using the new supercomputers which are now becoming available. Materials-by-design will replace the current approach of trial and error laboratory experimentation in which one material after another is tested until the one having the desired properties is found. The new approach allows scientists to first design the materials they want on a computer, and then use the computer-generated recipes to make the materials in the laboratory.

If this approach becomes widespread, our Nation's savings in time and money will be enormous. For example, it has been estimated in a recent Battelle Institute study that the petrochemical industry might save up to one-third of its annual capital expenditures by applying a materials-by-design approach to the development of optimal catalysts. That amounts to a savings on the order of $3 billion per year.

And they've—I recommend to the committee that Battelle report. It really is an interesting attempt to calculate what the value of these kinds of programs is in the long term. It's a very nicely done report and I'll not talk about the details. Some of the numbers are in my report and you can see them there.

But my feeling is that the materials-by-design is really vital to the Nation's leadership in technology. And in the areas that I just talked about, in materials, this is an area in which our competitors—particularly the Japanese—are making a major push forward. This is an approach which, I think, will actually allow us to stay in the forefront not only for now, but in the next 5 or 10 years.

Now, historically the capacity to innovate has been essential to our continued technological advancement and productivity gains. And if you look at a Brookings Institute study that was done in 1984, they talk about how you get increased productivity. They talk about economies of scale. You can expect to get perhaps 16 percent. You can do better resource allocation. You can get up to 12 percent. You can do better capital investment, improve your productivity by 16 percent. Education will make a major impact, up something like 12 percent. But technological innovation has the opportunity of making a 44-percent improvement in your productivity.

If you look at that, that's essentially the same as all of the other factors put together. So when we hear comments about productivity and effectiveness and competitiveness, one has to take these kind of order of magnitude things into consideration.

Now, I think, that the—that it's required to have a coordinated national program to make materials-by-design a tool which all scientists can use; whether they be academicians or whether they be in the industrial laboratories. To be truly effective, the effort must be at least as great as the one the United States is currently expending to develop the best supercomputers. In fact, materials-by-design should be considered the scientific software, and that's the scientific software use to which this hardware, the supercomputer hardware, will be put.

Now, the call for such an aggressive national effort is the result of several years of careful study by teams of leading scientists from universities, private sector laboratories, and Government agencies. The study was sponsored by DOE through ECUT, and we were privileged at the Signal Research Center to have part of the leadership role in developing that report.

Now, that document will appear in April of this year. We are in the process right now of drafting the final version of it. So it will be available for people to see and comment on. Some of my other testimony simply tries to point out why this approach is so very valuable.

You look at what Edison did, for example. If he had had the opportunity that we have today, he ought to be able—he should have been able to sit before his computer, describe the properties of the materials that he needed, and then he could actually test those materials in various environments, such as air or vacuum, and do that on the computer. With the information that's stored in the computer, and its tremendous computational power, he would have been able to identify a number of likely candidates for his filament.

If the data bank failed to find the right kind already existing, he could have used the computer to design new ones in three-dimensional color models. The quality of this approach is just fascinating. Now, only after identifying the likely candidates would he then have had to test those in his laboratory.

Now, Edison's actual achievement was the result of trial and error. That method of doing science, which is still the norm today, and particularly is still the norm in many industrial laboratories, is extremely time consuming and expensive. It requires an investment in basic materials, equipment, and instrumentation needed to test the likely candidates. Obviously, nothing gets tested deliberately unless one is reasonably sure it will work. This tends to discourage the testing of far out but perhaps innovative ideas gained from the literature search that precedes every experiment.

So the end result, it seems to me, is that materials-by-design is a logical extension of the scientific empirical method. It can really revolutionize the way in which we solve materials problems. It would be far faster and less expensive to perform the trial and error experimentation on computer rather than in the laboratory.

Now, why is it necessary to fund this right now? I think that's a good question. People talk about how we can delay. The reason really is that materials-by-design is at the moment very timely, because it's been made possible by the electronics revolution and by the advances in basic research in such fields as quantum chemistry and solid state physics.

Already a wide assortment of electronic instruments and techniques, such as scanning transmission electron microscopes and nuclear magnetic resonance, allows scientists to probe more deeply events at the atomic level. And for those of you who saw USA Today, there's a very interesting article in there this morning. Professor Crew's new electron microscope at the University of Chicago is now up and operating, and he can indeed see materials at atomic dimensions. So I recommend that you read the morning's edition of USA Today. It's a fascinating experiment.

So the point is that we have spent a lot of money and time getting ourselves to the position where this kind of an approach is possible and feasible. And to stop at this point, what will happen is our competitors will take all that data bank that we've put together—which they've done very effectively in the past—and they will do it instead. So it is really very important that we get the programs off the ground now and not delay them unduly.

I think, Mr. Chairman, with those comments, and with the understanding that the comments that I've made in my written statement will be in the record, that I will stop at that point and be happy to try to answer some questions if you have them.

[The prepared statement of Dr. Good follows:]

TESTIMONY
OF
DR. MARY L. GOOD
BEFORE THE
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
WASHINGTON, D.C.

March 6, 1986

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Louisiana State University 1954-1980
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Member and Past Member, various National Academy of Sciences and National Research Council Panels and Commissions; Member, boards of several institutes; Member, advisory panels for several universities; Authored more than 100 papers in refereed technical journals, several publications on science policy and research strategy, one book; Presented more than 200 invited lectures; Received numerous professional awards.

Testimony of
Dr. Mary L. Good

For Inclusion in the Record of
The U.S. House of Representatives Committee on Science and Technology
Hearings on Department of Energy Conservation Programs
Washington, D.C.
March 6, 1986

My name is Mary Good. I am President-Elect of the American Chemical Society. Thank you very much for this opportunity to comment on the Department of Energy's conservation programs. I am here to testify this morning in support of the DOE's Energy Conversion and Utilization (ECUT) program. This program capitalizes on the results of basic research.

I have long been on record in support of government funding for basic research and development. Some of these programs have been hard hit by the latest round of budget cuts. One is the ECUT program. ECUT is administered by the Deputy Assistant Secretary for Conservation and appears in the DOE's budget as part of the Multisector line item. Appropriations for the Multisector programs went from $25,574,000 for FY 1986 to a budget request of $19,850,000 for FY 1987. ECUT's support has decreased from $19 million to a budget request for $15.8 million during the same period.

The ECUT budget reductions just don't make sense in light of the excellent and necessary work that is being done. The ECUT program is designed to fill the gap between DOE's basic research (Basic Energy Science [BES]) programs and the time when private industry will aggressively pursue new technologies. ECUT, then, supports research to advance generic technologies. Specifically, the program assists the private sector by conducting research to expand industry's (and the nation's) technology base. This is a most appropriate role for the federal government, and has worked very well in the past. Quite frankly, without such federal cost-sharing and joint funding, industry would not move so rapidly in research programs with a national thrust.

Let me acknowledge here the opportunities that the Signal Research Center has had, under the ECUT program, to be at the cutting edge of several technologies. The Center has done some work in the area of biocatalysis and participated in a study to assess the value of a sustained program in Materials-by-Design. Unfortunately, after the proposals for the biocatalysis project were in, funding was taken away. That research is not going well.

At stake are not just a few isolated programs. The ECUT programs may turn out to be absolutely essential for our nation's technological leadership. The DOE's energy conservation programs were established in the 1970's in the aftermath of the oil crisis under the umbrella of the Non-Nuclear Act. This was no accident. Our energy resources are crucial to our technology. The future will belong to those who can produce and use new technology most efficiently.

ECUT's four interdisciplinary research programs are (see Appendix for a description of each):

- Materials
- Biocatalysis
- Tribology
- Combustion and Thermal Sciences

The underlying concept upon which this entire effort is based is called "**Materials-by-Design**". This concept involves the development of research tools to accelerate our Nation's capacity to innovate.

I would like to use Materials-by-Design to illustrate the value of ECUT's programs. It is a generic approach to solving technology problems that can be applied to all of the other ECUT programs. Materials-by-Design is a new way of doing science that promises radically new and vastly superior materials -- stronger, lighter, more energy efficient, and less expensive than anything known today.

Such breakthroughs will be possible using the new supercomputers which are now becoming available. Materials-by-Design will replace the current approach of trial and error laboratory experimentation, in which one material after another is tested until the one having the desired properties is found. The new approach allows scientists to first design the materials they want on a computer and then use the computer-generated recipes to make the materials in the lab. If this approach becomes widespread, our nation's savings in time and money will be enormous. For example, it has been estimated in a recent Batelle Institute study that the petrochemical industry might save up to one-third of its annual capital expenditures by applying a Materials-by-Design approach to the development of optimal catalysts. This amounts to savings on the order of $3 billion per year. Table 1 shows other examples.

TABLE 1

Summary of Cost Savings from Case Studies

for the Petroleum Refining and Petrochemicals Industries

if Ideal Catalysts are Used.

Capital Cost Savings

	Existing Processes ($ x 10^6)		Ideal Catalysts ($ x 10^6)		
Process	Per Pound	Total for 1983 Production	Per Pound	Total for 1983 Production	Percent Savings
Styrene	$0.25	$ 1.72 billion	$0.20	$ 1.4 billion	18
Alkylation	$0.15	$10.1 billion	$0.14	$ 9.4 billion	6

Operating Cost Savings

	Existing Processes ($ x 10^6)		Ideal Catalysts ($ x 10^6)		
Process	Per Plant	Total for 1983 Production	Per Plant	Total for 1983 Production	Percent Savings
Styrene	$71	$ 709	$12	$ 120	83%
Alkylation	$ 9.5	$1900	$ 4.2	$ 830	56%

Source: Batelle Pacific Northwest Laboratories study,

"Energy and Economic Savings from Improved Catalysts", January 1986.

Materials-by-Design is vital to our nation's leadership in technology. Historically, the capacity to innovate has been essential to our continued technological advancement and productivity gains. Table 2 indicates that technological innovation is the single most important factor for increasing productivity. Materials-by-Design promises to be the basis of revolutionary, technological innovation.

TABLE 2

Observed Productivity Increases.*

o Economics of Scale	16%	56%
o Better Resource Allocation	12%	
o Capital Investment	16%	
o Education	12%	
o Technological Innovation	44%	

*Brookings Institution study, 1984.

Because of intense international competition in technological arenas, it will take a coordinated national program to make Materials-by-Design a tool all scientists can use. To be truly effective, the effort must be at least as great as the one the U.S. is currently expending to develop the best supercomputer. Indeed, Materials-by-Design should be considered the scientific software use to which the supercomputer hardware will be put.

The call for such an aggressive national effort is the result of several years of careful study by teams of leading scientists from universities, private sector laboratories, and government agencies. The study was sponsored by DOE through ECUT and was directed and coordinated by the Signal Research Center Inc. Details of this work appear in the document, "Assessment of Theoretical and Experimental Tools for Applied Research and Exploratory Development in Certain Energy Technologies", to be released in April 1986.

The potential of the Materials-by-Design approach can be illustrated by considering how Thomas Edison might have used it to create a workable filament for the lightbulb. Edison spent years and alot of money searching for a material that would burn brightly, but would not burn up. Finally, the story goes, he found what he needed as he sat at his lab desk, idly rolling in his fingers some tar and lampblack into a thin strand. The strand worked well enough to lead Edison to try carbonized cotton thread and then bamboo filament in his first commercially successful incandescent bulb.

Materials-by-Design would have permitted Edison to sit before his computer, describe the properties of the material he needed, and even to test these properties in various environments such as air or vacuum. With the information stored in the computer and its tremendous computational power, he would have been able to identify a number of likely candidates for his filament. If the databank failed to find the right kind already existing, he could have used the computer to design new ones, in three dimensional color models. Only after identifying the likely candidates would he have tested them in his laboratory.

Edison's actual achievement was the result of trial and error in the laboratory. That method of doing science, still the norm today, is extremely time-consuming and expensive. It requires an investment in the basic materials, equipment, and instrumentation needed to test the likely candidates (which might have quite different requirements). Obviously, nothing gets tested deliberately unless one is reasonably sure it will work. This tends to discourage the testing of "far out" but perhaps innovative ideas gained from the literature search that precedes every experiment.

As the questions and answers of science become more complex and as the pace of technological change accelerates, we cannot afford the luxury of using this tried and true, but awkward, method in its present form. Now, our nation is better served by a system that pushes state-of the-art technology ahead by giant leaps rather than by inches. Materials-by-Design is a logical extension of the scientific empirical method. At the same time, it can revolutionize the way we solve materials problems. It would be far faster and less expensive to perform the trial and error experimentation on computer rather than in the laboratory.

Materials-by-Design has been made possible by the electronics revolution and by advances in basic research in such fields as quantum theory and solid state physics. Already, a wide assortment of electronic instruments and techniques, such as scanning transmission electron microscopes and nuclear magnetic resonance spectroscopy, allows scientists to probe, more deeply, events at the atomic level. Combining these tools with computer modeling, scientists can reliably predict how a particular material or groups of materials will behave under a specific set of conditions.

The ECUT study examined how Materials-by-Design would affect three critical areas of science: Catalysis, materials science, and tribology (the science of lubricants and bearings). Our awareness of the high technological potential of all three areas stems from the new understanding advanced instrumentation has allowed us of the chemistry and physics occurring at the surfaces of materials.

How would the Materials-by-Design approach improve the field of catalysis? Catalysts -- materials that speed up chemical reactions -- are the workhorses of modern civilization. More than 20% of the U.S. GNP is driven by catalytic processes in one way or another. Catalysts are used in virtually every manufacturing process -- for food, pharmaceuticals, fabrics, fuels, and fertilizers. Catalysts are also used extensively in environmental protection devices to trap toxic components of automotive exhaust fumes and power plant stack gases. No wonder researchers are trying to make catalysts work better. Improved catalysts, which speed up industrial processes, conserve energy and increase productivity.

The Batelle Institute's 1986 report cited above states that a major U.S. effort is warranted to push the Materials-by-Design approach for catalysts. Batelle's initial estimates reveal a potential capital cost savings of $31 billion and operating cost savings of $69 billion for chemical and petroleum plants over fifteen years. According to the report, such an effort should be made on behalf of catalyst materials "to ensure preeminence by U.S. industry".

According to the Batelle report, other benefits of improved catalysts would allow 1) the greater use of alternative feedstocks, such as coal and biomass, reducing U.S. dependence on foreign petroleum imports and 2) development of new chemicals and processes, for example, the production from waste materials of non-air-polluting hydrogen for fuel.

To understand how a particular catalyst changes a chemical reaction between two other materials, scientists must be able to "see", on the atomic and subatomic levels, what chemistry and physics occur at the catalyst surface. Until recently, it has been difficult to discover what is happening at these catalytic sites because the chemically reacting substances get in the way. Now, researchers can use supercomputers to model the catalytic sites. The computers can do the complex calculations that express how such factors as pressure and temperature affect surface processes, and describe the relationship between one atom in the material and every other atom.

The calculations have been impossible to do on ordinary computers -- they simply take too much time. As researchers learn more about predicting surface behavior under specific conditions, they will build a complete theoretical framework from which they can extrapolate even more information.

The same kinds of problems exist in the fields of materials science and tribology. The same understanding of surface atomic processes we need for designing new materials could be applied to reducing wear and drag caused by friction between two surfaces in gears, cams, and bearings. It could lead to the production of engines and other machines that need no lubricating oils. Such a development would provide a tremendous advantage for this nation's products in the international marketplace.

A Materials-by-Design approach could enable us to create new alloys and coatings that are superior to those in use today. Better thermal insulation coatings could provide protection from heat and other energy loss. Anti-oxidative coatings and paints could cut significantly the billions of dollars in damage that corrosion causes annually. And again, since paints and other coatings are applied to the surfaces of materials, to make them work, we must understand the physical and chemical processes occurring at the surface.

To our Nation, the potential value of Materials-by-Design is much more than achieving technological leadership in a few technical areas. Its full potential will be realized in the broad application of this approach to other kinds of problems. This can only happen when scientists in every area of research have access to supercomputers and advanced instruments. Right now, there is not enough high level electronic equipment to go around. It is one of our national strengths that we have so many ideas about how to solve a vast array of complicated research problems. But how do we choose which problems are most deserving of our resources?

For this we need a national commitment to making these decisions in a rational, coordinated way. We need to decide who will make the decisions -- government? The private sector? A combination? Should government fund this kind of national technological push? Should scientists alone set the research priorities or ought others participate in a matter of such national importance? These questions were outside the original scope of the ECUT study. While those involved may not even agree on the questions, much less the answers, there is a consensus that these issues must be faced now.

In the early part of this century, scientists began to understand the nature of the atom. They used that information to explain how things work. Now, we are on the threshold of using atomic theory to design new technology. Materials-by-Design may be one of the most significant scientific advances in this century. We must not miss the opportunities it promises.

Appendix

Brief Summary of ECUT Research Programs

Materials. The ECUT Materials Program seeks to identify and develop likely new energy-conserving materials and processes. Researchers are building a database of the materials' properties and performance characteristics as they develop the materials to the point where industry can use them. Some of these materials are metallic alloys that researchers are trying to improve for better performance at high temperatures. Other projects concentrate on reducing defects in ceramic materials and devising new methods to join ceramic components. Materials-by-Design is a computer modeling approach to creating new materials.
It enables scientists to predict the properties of a set of molecules or atoms based on the bonding and structural relationships among them. ECUT supported a study to assess this infant science's potential value for energy conservation.

Biocatalysis. An Office of Technology Assessment (OTA) report described applied research in bioprocess engineering as an area on which the U.S. competitive advantage in biotechnology may depend. ECUT's biocatalyst projects anticipate the nation's need. Genetic engineering has made it possible to design microorganisms that produce specific enzymes (biocatalysts). Just as in living systems, these enzymes can theoretically be used to carry out a chemical process more efficiently. The biocatalyzed chemical reaction processes will use less energy and produce more of the desired material than conventional chemical processes. ECUT's research seeks to solve the technical problems of using these biologically-derived enzymes to produce materials such as chemicals in a more efficient and less energy-intensive manner than can be done now.

Tribology. Much energy is lost through friction created when the moving parts of machinery rub against each other. ECUT's Tribology Program explores the chemistry and physics of moving surfaces and seeks to understand the mechanisms of friction and wear. Researchers are applying new lubrication and surface modification techniques, including coatings, to reduce wear on machinery components. The results of this generic research is expected to effect major energy savings in the transportation, residential, industrial, and utility sectors of the U.S. economy.

Combustion and Thermal Sciences. ECUT's charge in this area is to promote the design and development of energy-conserving combustion systems and devices. Combustion is the fundamental process for converting fuels into useable energy. Despite a great deal of research and study in the past, combustion has not been well characterized. If we can improve our understanding of the basic principles of this subject, then we can improve our use of it for more efficient industrial processes. Heat lost during energy use is wasted energy and also results in low process efficiency. ECUT's thermal science research aims to build a comprehensive database for industry to use in designing energy conversion systems that salvage wasted heat. Research groups include scientists from university, industrial, and DOE laboratories.

Mr. Fuqua. Thank you very much, Dr. Good. And we'll hear from our other two panelists and then we'll go to questions. And at this time I would like to recognize our colleague from Pennsylvania to introduce our next witness.

Mr. Ritter. Thank you, Mr. Chairman. It's a pleasure to be here and I enjoyed your testimony, Dr. Good. I'd like to just introduce my constituent and good friend, Dr. Jim Leonard. Dr. Leonard is a kind of new boy on the block in the steel industry. He comes out of a background in manufacturing at Westinghouse, manufacturing at Allis-Chalmers. He knows the capital goods side of the business. He's been a director of a laboratory at a major university and a chairman of the department. He's worked over the years with Government programs.

He really brings a unique perspective to the technology problems of the steel industry. And I think what he has to say today, as far as I'm concerned, it is probably the most important thing that could be said about the steel industry and what needs to be done. He is looking toward the future. His ideas are oriented toward the future. And while we try to hold the line to keep the steel industry surviving today, the future has a lot more to it, a lot more potential than simply holding the line or hanging on with our fingernails.

So, Dr. Leonard, it's a pleasure to be here and listen to your testimony today. And I'm sure my colleagues will find it very interesting.

Thank you. Thank you, Mr. Chairman.

Mr. Fuqua. Thank you. And, Dr. Leonard, we'll be pleased to hear from you.

STATEMENT OF DR. JAMES H. LEONARD, VICE PRESIDENT FOR TECHNOLOGY, BETHLEHEM STEEL CORP.

Mr. Leonard. Thank you, Mr. Chairman and Mr. Ritter, for those kind words.

Mr. Fuqua. You'll have to pull that just a little closer to you.

Mr. Leonard. I serve as vice president of technology for Bethlehem Steel Corp., and also currently as chairman of the American Iron & Steel Institute's committee on technology. I am appearing today on two separate matters, and I will need to make clear from whence I am speaking on each of these two matters.

The first matter is to respond to the request from this subcommittee for a status report on the steel industry/national laboratories initiative which was authorized by this committee as part of the DOE fiscal year 1986 budget. The second matter is to recommend funding for certain long-range steel technology developments in the proposed DOE fiscal year 1987 authorization request for conservation programs.

Now, the first thing to say is if the American steel industry is to have any chance of maintaining a long-term competitive position, then development and utilization of superior advanced technology will be an essential factor in the international marketplace. This is especially true in light of the support our foreign competitors are receiving from their governments in new technology development, about which I will have more to say just a little later.

Now, on this first matter, the steel industry/national laboratories initiative, which has been called by some the Keyworth Initiative, I will give a status report based on meetings of the joint American Iron & Steel Institute and National Laboratory Steering Committee on this initiative which last met in February 20, 1986.

Although approximately $7.4 million was appropriated for this initiative in the Department of the Interior and Related Agencies Appropriations Act for fiscal year 1986, which was signed by the President in December last year, no funding has yet been made available for this purpose by the Department of Energy. In fact, the entire amount has been deferred in the fiscal year 1987 energy conservation budget which was proposed in January. Accordingly, Mr. Chairman, I can report only limited progress in implementing this particular cost sharing program in response to your letter to me of February 21.

However, in spite of the lack of funding to date, the Steering Committee and the two task forces which have been established to define the technical content of the project have continued to meet. As a result of these meetings, and from some preliminary studies, broad parameters of the proposed technical content have been defined.

Especially notable has been the development of a concept for magnetic containment for possible use in shaping and feeding of liquid steel to produce a casting without physically touching it with a mold. That development offers promise for a substantial departure from other technical avenues for improved casting technology. And the United States has unique capabilities for developing this concept in our national laboratories.

This is a good example of the objective of the Keyworth concept in which this national resource—meaning the national laboratories—of outstanding talents and facilities can be used for achieving international competitive advantage in a basic manufacturing industry which is currently experiencing extreme pressure from overseas competitors backed by their national governments. We need to find a way, despite our current deficit difficulties, to mobilize and utilize this unique resource to help the struggling steel industry. Funding for this initiative should be reinstated for fiscal year 1986 and continued for fiscal year 1987.

Now, on the second matter I can, necessarily, speak only for Bethlehem Steel because it will be apparent that the specific interests of individual domestic steel companies are involved. In fact, this testimony I will now present was previewed by representatives of those domestic steel companies active on the AISI's committee on technology. And the result of this preview was full concurrence by six companies, partial concurrence by one, and no concurrence by one company. That is why I emphasize that I am now speaking as a representative of Bethlehem Steel with the support of certain companies, as I just indicated.

Last year, Congress also approved continuation of two projects related to steel industry energy conservation for a total of $8 million. These are the United States Steel/Bethlehem Steel thin slab casting project, and the Armco/Westinghouse thin strip casting project. The 1987 budget request by DOE anticipates concluding these projects in 1986.

Assuming an indefinite deferral of the steel industry/national lab initiative along with this, support for steel related energy conservation programs would thus drop from $15.4 million in fiscal year 1986 to zero in fiscal year 1987. Funding for these programs must continue in order to achieve the initial goals of significant energy savings—as much as 15 percent—and operating and capital cost savings—as much as 20 to 30 percent—in order to help restore our international competitiveness.

The 1987 budget proposed by DOE for research in conservation mentions the concept of cooperative R&D ventures with industry for "technology-transfer/proof of concept" activities to strengthen whole industries. These ventures would apparently be as an alternative to DOE funding of specific projects, as was the case in the 1986 budget.

The Department of Energy contemplates "reprogramming of moneys" to participate in promising cooperative ventures in response to industry proposals. Now, preliminary discussions have been held with DOE by steel industry companies in response to this suggestion, and further meetings are anticipated. Representatives of several steel companies have been discussing whether this concept has any applicability as a means for pursuing development of so-called leapfrog steel technologies to gain an internationally competitive position.

It is too early to report any specifics, but I believe chances are good that several companies may attempt to form a cooperative technology development entity relatively soon. It may be that the Department of Energy's apparent interest in cooperative R&D ventures will serve as a catalyst to get this off the ground.

The purpose of such a joint industry-Government cooperative venture would be, as I understand it, to leverage R&D funding among companies such that a critical mass would be formed which could lead to breakthroughs in leapfrog technology. The fiscal condition of the domestic steel industry is such that no one company has the resources to do this alone, but a group of companies can do it with Government help. To restore our international competitiveness, we need breakthroughs in several technologies.

No single technology development can be foreseen to yield sufficient cost savings to gain substantial international advantage. To do this would require cost savings of at least $50 to $100 per ton of steel to overcome labor rate differentials between the United States and our major competitors. Without a program of sufficient size, smaller incremental improvements in technology just won't be enough.

Our foreign competitors fully recognize the importance of new technology. In Japan, the Ministry of International Trade and Industry, working with the five largest Japanese steel companies, has instigated a new national research effort with an initial government funding of $65 million. In Germany, the Federal Ministry of Technology and Research is funding up to 90 percent of a similar program. If we don't embark on our own program now, we will undoubtedly lose in this international technology race.

What is needed is a joint industry-Government crash effort extending over a period of 4 to 5 years working on at least three technology areas simultaneously; reduction and refining, casting, and computer integrated production.

Possibilities in the reduction/refining area which have been considered include direct ironmaking, which bypasses the coking operation; direct steelmaking, which bypasses both the coking and ironmaking stages; and single stage scrap melting and purifying, which would permit the use of inexpensive domestic scrap—one of our country's unique raw materials—to be processed directly to high quality steel.

In the casting area, possibilities include magnetic casting, as I mentioned earlier, thin-slab casting, and thin-strip casting. Computer integrated steel production requires the development of sensors and process control systems to integrate production and quality control. The development of some of these technologies has been or would have been supported by Government funding under the DOE and National Bureau of Standards 1986 budgets; for example, direct steelmaking and magnetic casting under the steel initiative, with most of the work being done at the national laboratories; also thin-slab casting, with work performed at both United States Steel and Bethlehem Steel laboratories; and thin-strip casting conducted at Armco and Westinghouse; and sensor development at the National Bureau of Standards laboratories.

An effort of sufficient scope to achieve sufficient cost savings to alter the international situation would, in my mind, require the full-time efforts of the best 250 research scientists from the steel industry, Government laboratories, and other sources, including universities. This equates to about $25 million per year for personnel costs. Equipment and other costs are probably of the same order of magnitude. Thus, a 4 to 5 year effort through the proof-of-concept phase would cost between $200 and $250 million.

Under the cooperative venture concept suggested by DOE, and assuming that the Government and the steel industry share these costs equally, we're talking about roughly $25 million per year from each. It should be emphasized that consistent with provisions of the existing Government supported steel-related programs, the Government share of funding would be paid back from royalties after the new technologies have been demonstrated and reduced to practice.

It is reasonable to expect that the cost of full-scale demonstration plants, beyond the proof-of-concept phase, would be privately funded if the preliminary development work indicates sufficient competitive advantage could be gained by implementing the new technology.

The key to this effort will be rapid and temporarily exclusive utilization of the technology developed by domestic steel companies electing to participate. Specifically, it would be essential that the technology and equipment designed would have to be treated as proprietary information so that exclusive use could be maintained for a period of some years, perhaps 10, in order to sustain a satisfactory financial return on the investments.

Without this protection, the value of the whole effort will be weakened. Whether this can be accomplished in a cooperative venture with Federal funding participation is a key question that must be addressed if the cooperative concept is to have any applicability to attaining international competitive positions in basic, import-impacted industries such as steel.

May I emphasize that I am not asking this committee to approve Government funding for this effort in the whole. I believe that there are other possible sources for funding, private and public, including the Electric Power and Gas Research Institutes, and possibly other Government agencies.

What I am asking, however, is for this committee to reinstate the fiscal year 1986 funding for the Steel Initiative, which has been deferred, and to continue funding in fiscal year 1987 for steel-related energy conservation programs at the $15.4 million level authorized for fiscal year 1986. This will provide nearly one-third of the funding needed for the crash program I've described. If required, this funding level could, I believe, be apportioned on a priority basis among the projects I have described as part of a cooperative venture approach.

I want to stress that, considering the activities of our foreign competitors in the technology area, the program I have proposed is the U.S. steel industry's only shot at gaining a long-term competitive advantage over our international competition based on technology. We'll never be lower in labor cost than our overseas competitors, who also have access to the same existing worldwide technologies as we do.

So, superior new technology from this proposed program is the only longer term bet we have. In effect, we're betting that our scientists in industry, Government, and universities can beat the foreign competition.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Leonard follows:]

Statement by
James E. Leonard, Vice President, Technology
Bethlehem Steel Corporation
Before the U.S. House of Representatives
Subcommittee on Energy Development and Applications
March 6, 1986

Mr. Chairman, my name is James E. Leonard, Vice President for Technology, Bethlehem Steel Corporation. I also currently serve as Chairman of the American Iron and Steel Institute's Committee on Technology. I am appearing today on two separate matters. The first is to respond to the request from this Subcommittee for a status report on the "Steel Industry/National Laboratories Initiative" which was authorized by this committee as part of the DOE FY 1986 budget. The second is to recommend funding for certain long range steel technology developments in the proposed DOE FY 1987 authorization request for Conservation programs.

Both of these programs are essential if the American steel industry is to have any chance of maintaining a long-term competitive position in technology in the international marketplace. This is especially true in light of the support our foreign competitors are receiving from their governments in new technology development, about which I will have more to say later.

On the first matter -- the Steel Industry/National Laboratories Initiative (called by some the "Keyworth Initiative") -- I will give a status report based on meetings of the joint AISI/National Laboratory Steering Committee on the Initiative which last met on February 20, 1986.

Although approximately $7.4 million was appropriated for this initiative in the Department of the Interior and Related Agencies Appropriations Act for FY 1986, which was signed by the President on December 20, 1985, no funding has yet been made available for this purpose by the Department of Energy. In fact, the entire amount has been "deferred" in the FY 1987 Energy Conservation budget which was proposed in January. Accordingly, Mr. Chairman, I can report only limited progress in implementing this cost-sharing program in response to your letter to me of February 21st.

However, in spite of lack of funding to date, the steering committee and the two task forces which have been established to define the technical content of the project have continued to meet. As a result of these meetings and from some preliminary studies, broad parameters of the proposed technical content have been defined. Especially notable has been the development of a concept for magnetic containment for possible use in shaping and feeding of liquid steel to produce a casting without physically touching it with a mold. That development offers promise for a substantial departure from other technical avenues for improved steel casting technology, and the United States has unique capabilities for developing this concept in our National Labs. This is a good example of the objective of the Keyworth concept in which this national resource of outstanding technical talents and facilities can be used for achieving international competitive advantage in a basic manufacturing industry which is currently experiencing extreme pressure from overseas competitors backed by their national governments.

We need to find a way, despite our current deficit difficulties, to mobilize and utilize this unique resource to help the struggling steel industry. Funding for this initiative should be reinstated for FY 1986 and continued for FY 1987.

On the second matter, I can, necessarily, speak only for Bethlehem Steel, because it will be apparent that the interests of individual domestic steel companies are involved.

Last year, Congress also approved continuation of two projects related to steel industry energy conservation for a total of $8 million - these are the U.S. Steel/Bethlehem Steel thin slab casting project and the Armco/Westinghouse thin strip casting project. The 1987 budget request by DOE anticipates concluding these projects in 1986. Assuming an indefinite "deferral" of the Steel Industry/National Lab Initiative, support for steel-related energy conservation programs would drop from $15.4 million in FY '86 to zero in FY '87. Funding for these programs must continue in order to achieve the initial goals of significant energy savings (as much as 15%) and operating and capital cost savings (as much as 20-30%) in order to help restore our international competitiveness.

The 1987 Budget proposed by DOE for research in Conservation mentions the concept of cooperative R&D ventures with industry for "technology-transfer/proof of concept" activities to strengthen whole industries. These ventures would apparently be as an alternative to DOE funding of specific projects, as was the case in the 1986 budget. The Department of Energy contemplates "reprogramming of monies" to participate in promising cooperative ventures, in response to industry proposals. Preliminary discussions have been held with DOE in response to this suggestion, and further meetings are anticipated. Representatives of several steel companies have been discussing whether this concept has any applicability as a means for pursuing development of "leapfrog" steel technologies to gain an international competitive position. It is too early to report any specifics, but I believe chances are good that several companies may attempt to form a cooperative technology development entity relatively soon. It may be that the Department of Energy's apparent interest in cooperative R&D ventures will serve as a catalyst to get this off the ground.

The purpose of such a joint industry-government cooperative venture would be, as I understand it, to leverage R&D funding among companies such that a critical mass would be formed which could lead to breakthroughs in "leapfrog" technology. The fiscal condition of the domestic steel industry is such that no one company has the resources to do this alone; but a group of companies can do it with government help. To restore our international competitiveness we need breakthroughs in several technologies.

No single technology development can be foreseen to yield sufficient cost savings to gain substantial international competitive advantage. To do this would require cost savings of at least $50-100/ton of steel to overcome labor rate differentials between the U.S. and our major competitors. Without a program of sufficient size, smaller incremental improvements in technology won't be enough.

Our foreign competitors fully recognize the importance of new technology. In Japan, the Ministry of International Trade and Industry, working with the 5 largest Japanese steel companies, has instigated a new national research effort with an initial funding of $65 million. In Germany, the Federal Ministry of Technology and Research is funding up to 90% of a similar program. If we don't embark on our own program now, we will undoubtedly lose in this international technology race.

What is needed is a joint industry-government "crash" effort, extending over a period of 4 to 5 years, working on at least 3 technology areas simultaneously - reduction/refining, casting, and computer-integrated production. Possibilities in the reduction/refining area which have been considered include direct ironmaking (bypassing the coking operation), direct steelmaking (bypassing both the coking and ironmaking stages), and single-step scrap melting/purifying (which would permit the use of cheap domestic scrap - one of our country's unique raw materials - to be processed directly to high quality steel). In the casting area, possibilities include magnetic casting, thin-slab casting and thin-strip casting. Computer-integrated steel production requires the development of sensors and process control systems to integrate production and quality control. The development of some of these technologies has been or would have been supported by government funding under the DOE and NBS FY '86 budgets, e.g., direct steelmaking and magnetic casting under the "steel initiative", with most of the work being done at the National Laboratories (Argonne and Oak Ridge); thin slab casting, with work performed at both U.S. Steel and Bethlehem Steel laboratories; thin-strip casting, conducted at Armco and Westinghouse; and sensor development at NBS laboratories.

An effort of sufficient scope to achieve sufficient cost savings to alter the international competitive situation would, in my mind, require the full time efforts of the best 250 research scientists from the steel industry, government laboratories and other sources, including universities. This equates to about $25 million/year for personnel costs. Equipment and other costs are probably of the same order of magnitude. Thus a 4 to 5 year effort through the "proof-of-concept" phase could cost between $200 and $250 million. Under the cooperative venture concept suggested by DOE and assuming that the government and the steel industry shared these costs equally, we're talking about roughly $25 million per year from each. It should be emphasized that, consistent with provisions of the existing government-supported steel-related programs, the government share of funding would be paid back from royalties after the new technologies have been demonstrated and reduced to practice. It is reasonable to expect that the cost of full-scale demonstration plants, beyond the proof-of-concept phase, would be privately funded if the preliminary development work indicates sufficient competitive advantage could be gained by implementing the new technologies.

The key to this effort will be rapid and temporarily exclusive utilization of the technology developed by domestic steel companies electing to participate. Specifically, it would be essential that the technology and equipment design would have to be treated as proprietary information, so that exclusive use could be maintained for a period of some years, perhaps 10, in order to sustain a satisfactory return on the investments. Without this protection, the value of the whole effort will be weakened. Whether this can be accomplished in a cooperative venture with federal funding participation is a question that must be addressed if the cooperative concept is to have any applicability to attaining international competitive positions in basic, import impacted industries such as steel.

May I emphasize that I am not asking this Committee to approve government funding for this effort in toto. I believe that there are other possible sources of funding, private and public, including the Electric Power and Gas Research Institutes and, possibly, other government agencies. What I am asking, however, is for this committee to reinstate the FY '86 funding for the "steel initiative" which has been deferred, and to continue funding in FY '87 for steel-related energy conservation programs at the $15.4 million level authorized for FY '86. This will provide nearly one-third of the funding needed for the "crash program" I described earlier. If required, this funding level could, I believe, be apportioned on a priority basis among the projects I have described as part of a cooperative venture approach.

I want to stress that, considering the activities of our foreign competitors in the technology area, the program I have proposed is the U.S. steel industry's only shot at gaining a long term competitive advantage over our international competition based on technology. We'll never be lower in labor cost than our overseas competitors, who have access to the same existing worldwide technologies as we do. So superior new technology from this proposed program is the only longer term bet we have! In effect, we're betting that our scientists, in industry, government and universities, can beat the foreign competition!

Thank you.

Mr. **Fuqua**. Thank you very much, Dr. Leonard. Mr. Howard.

STATEMENT OF ROBERT C. HOWARD, THERMO ELECTRON CORP.

Mr. **Howard**. I appreciate the opportunity to give Thermo Electron's view on the DOE conservation budget we have worked with—for probably since its inception. We have focussed on the industrial energy portion of the DOE's conservation budget. In fact, Thermo Electron's primary business is the development and sale of products which improve efficient use of energy in industry. And we have worked on many programs with the conservation group to develop products that can do this.

We find that using innovative devices and processes designed to reduce energy consumption in industry not only lowers costs, but frequently improves product quality and overall industrial productivity. We're involved in equipment not only for the steel industry, but the paper industry, the automobile industry, the tool industry. We serve many different segments of American industry with equipment that is aimed at reducing energy costs.

The lagging productivity growth in the United States is certainly a major contributor to our worsening position in the world competition. Our major competitors, as Dr. Leonard just mentioned, in Japan and others, provide substantial support for long-term research aimed at improving the competitive strength of their industries. In fact, Japan's overall productivity currently is improving at nearly three times the rate at which U.S. industry's productivity is improving.

The conservation research sponsored by DOE is one of the few federally funded efforts aiding the competitive position of U.S. industry. There are many opportunities to develop products and technologies to increase our industrial productivity, some of which are mentioned in the prepared testimony, that Thermo Electron is working on, but there's many others.

However, most of these involve high risk and long lead time, and therefore they're not attractive investments for private companies, such as Thermo Electron, to do all on their own. DOE's past investments in these ventures I think have been quite successful, some of it at our company and many at others.

And I'd like to bring attention to one such investment they've made in the field called cogeneration, which I think most of you are familiar with. As you know, cogeneration, when properly employed in industry, can save fuel costs, capital costs, fuel costs of electricity, and thermal power; can cut it by as much as 50 percent.

And if I can call attention to the pictures that were supplied with the testimony, the cost of electricity—the electric bill for industry—has gone up by a factor of 10 in the last 15 years. In 1970, it was approximately $5 billion and now it's over $60 billion. It has now become an appreciable part of product cost. In some industries, of course, it's a lot more. These are averages for the whole, for all of American industry.

So cogeneration, by being able to reduce the cost of electricity for American industry, can play a very key role in increasing productivity. This was recognized in the late 1970's and early 1980's by many people, but industry was slow to pick it up. They were hesitant to make the kind of investments and take the risks that were required.

The conservation group of DOE stepped in, encouraged the use, supported new technology development in cogeneration, and finally participated in actual demonstration plants, one of which Thermo Electron was involved in, a very successful plant in a vitamin C plant in New Jersey.

As a result of—partly as a result of the DOE conservation group's help, cogeneration has now become a very growing and prosperous industry in the United States, and it is doing much to lower the cost of electric power for American industry and also thermal power.

We are currently involved, Thermo Electron is currently involved, in about six programs with DOE conservation which total about $2 million a year, and which represents about 8 percent of our total research budget, and we cost share in some of these programs with DOE. All of these programs relate to improved efficiency in industrial energy utilization. And I've described these programs in the testimony.

If all of these programs were successful, the savings in industrial energy use would be measured in hundreds of millions of barrels of oil per year, a handsome pay back from a national point of view. But, as I said, they involve risk and some of them are long term.

If DOE's conservation budget were cut severely, as evidenced in the administration's request, and caused some or all of these programs to be terminated, a substantial past investment in these programs would be lost and, of course, future benefits would not materialize, and the technology and the engineering teams would be lost. It would be very difficult to rebuild these at a future date; not only difficult, but time consuming and costly.

I strongly recommend that the cuts in these and other DOE conservation programs be limited to the order of 15 percent of 1985 levels. This way the programs will be stretched out, but the work that's gone on thus far will not be lost, the investment will be preserved. Some other country won't come along and pick up how far we've gotten and take it from there. And I think when these programs are successfully developed, they will give U.S. industry some help that it badly needs in the world competition.

Thank you.

[The prepared statement of Mr. Howard follows:]

TESTIMONY OF
ROBERT HOWARD, EXECUTIVE VICE PRESIDENT
THERMO ELECTRON CORPORATION
BEFORE THE SUBCOMMITTEE ON SCIENCE AND TECHNOLOGY
COMMITTEE ON AUTHORIZATIONS
U.S. HOUSE OF REPRESENTATIVES
March 6, 1986

Mr. Chairman and Members of the Subcommittee:

This testimony is offered on behalf of the manufacturing industries in the United States. I represent a company whose primary business is the efficient use of energy in industry. This statement is directed to the 1987 Authorization for the Department of Energy, Deputy Assistant Secretary for Conservation. Specifically, I recommend that this authorization include Industrial Energy Conservation funding at a level equal to 85 percent of the 1986 appropriated level to maintain continuity in energy conservation technologies which have broad application and are of paramount importance to manufacturing in this country.

The term energy conservation research is probably a poor choice of words to describe DOE's effort, for it evokes memories of the curtailment and sacrifice mentality that emerged with the oil shortages over a decade ago. In fact, most such research yields improvements in energy efficiency and in other measures of productivity as well. Innovative devices and processes, designed to reduce energy consumption, often produce even greater economic benefits through reduced capital cost, higher reliability, improved product quality, or lower labor costs.

Lagging productivity growth in the U.S. is a major contributor to our worsening position in world competition. The problem is no longer confined to so-called smokestack industries--its impact is now being felt in many high technology industries as well. During the first half of 1985, the U.S. trade deficit ran at an unprecedented annual rate of $125 billion. As a result, we became in August a debtor nation for the first time since 1914.

Many of our foreign competitors, Japan in particular, are able to provide substantial support for long-term research targeted at improving the competitive strength of their industries. This practice, coupled with financial policies designed to minimize the cost of business capital, have helped to produce large annual increases in productivity. Currently, for example, Japan's productivity is gaining at a rate nearly three times that of our own.

It is, of course, relatively easy for Japan to provide broad support to commercial R&D because they do not require the large defense outlays needed to meet U.S. global committments. Our defense research does provide indirect fallout benefits to the commercial sector, but the impact of these expenditures upon our overall productivity problem is probably very small. DOE's conservation research is one of the few Federally funded efforts having a non-defense focus. Any deep cuts in this program would therefore be particularly harmful, and American industry will face yet another hurdle in its struggle with subsidized foreign competitors. However, a 15 percent cut should be tolerable without great harm being done.

The effectiveness of past DOE sponsorship in conservation-related programs has been encouraging. We and others received support from DOE several years ago in developing technology for cogeneration systems that could reduce the capital and fuel costs of generating electricity by 50 percent. Industry was reluctant to invest in cogeneration systems until DOE encouraged and supported such systems through technology and direct investments in demonstration plants. Partly as a result of these efforts, cogeneration is now an important and rapidly growing business in the U.S., providing many jobs and significantly lower power cost for segments of American industry. Thermo Electron is a major contributor to this business, having designed and built many cogeneration plants ranging in size from 60 kilowatts to 25 megawatts. This success in cogeneration was greatly aided by Congress's continued concerns regarding energy conservation.

At this point, I would like to review some specifics of the current DOE sponsored conservation programs at Thermo Electron. Two of these projects are directed at recovering heat from the flue gases of industrial furnaces where the exhaust is too dirty and corrosive for existing heat exchangers. Examples include furnaces which remelt and alloy scrap aluminum, glass furnaces, steel forging furnaces and ingot soaking pits. In the U.S. aluminum industry alone, there are over 200 furnaces operating with 2200°F flue gases. Currently, there is no equipment available to recover this high grade energy which is equivalent to at least five million barrels of oil per year.

Our fluidized bed waste heat recovery system represents one possible solution to this problem. In this system, small particles are heated by passing them down the furnace exhaust stack. They are then removed and used to heat the combustion air going to the furnace. Energy savings are in excess of

30 percent. The advantage of this system is that particle materials can be used that are compatible with the flue gases. These same materials cannot be fabricated into conventional heat exchanger designs. Due to the unconventional approach, technical risks are high, so without DOE support the system would not be developed.

Our composite heat exchanger offers another means of recovering high temperature furnace heat. Here we are using a new material technology, developed in the Thermo Electron R&D Center, which may allow us to make the heat exchanger along more conventional lines. This technology involves the Chemical Vapor Depostion of Silicon Carbide to fabricate composite structures into the complex shapes needed in a heat exchanger. If successfully developed, it will have better thermal and mechanical properties than any other known approach.

In addition to these heat exchanger projects, we are working on several other developments for DOE. I will not go into much detail here, but the following list provides some idea of the nature of our research:

- Replacement of oil with coal-water slurry fuels in large slow-speed diesel cogeneration engines which will broaden the applications for this country's vast coal deposits and provide fuel savings potential equivalent to at least 100 million barrels per year.
- Recovery of heat from low temperature contaminated steam by means of a twin falling-film heat exchanger with equivalent energy savings potential of 65 million barrels of oil per year.
- Topping cycle cogeneration of electricity using combustion heated thermionic converters in conjunction with gas turbines or high

temperature industrial furnaces with the potential of improving electric power generation efficiencies by 15 percent.

- Improvement of boiler combustion efficiency by means of flame analyzer/controllers applied to individual burners rather than to the bulk flue gases with potential energy savings equal to two percent of the nation's total boiler consumed BTU's.

Total DOE support at Thermo Electron for the projects I have mentioned amounts to about $1.9 million in fiscal 1986, or roughly eight percent of our total research budget. It is important to note that these sponsored programs, due to their high risk and long lead time, could not be supported solely by private funds, even though they offer to the Nation potentially large dividends in energy productivity. If severe cuts were made in these programs causing some to be terminated, the nation would lose the benefit of all the progress made thus far. The investment in technology and in the development of the engineering and scientific teams would be lost. Rebuilding these teams and resurrecting the technology would be very difficult, time consuming, and costly. The repeated changing of priorities in development programs of national importance can be extremely wasteful and discouraging to those who are striving to make the programs a success. I strongly recommend that we complete these promising developments and thereby preserve the substantial investment already made in these programs.

Mr. **Fuqua**. Thank you very much, Mr. Howard. What extent are you involved in—your company—in cogeneration activities, particularly the principal fuel that's being used? And is that—you mentioned $2 million.

Mr. **Howard**. The $2 million are the programs——

Mr. **Fuqua**. Is that DOE funded or——

Mr. **Howard**. These are the current level of funding for DOE programs that we have right now. We are involved in a number of large cogeneration projects which use technology that has already been developed. These are in the commercial industrial sector.

Mr. **Fuqua**. And can you—including these programs and probably some others that you're involved in, could you identify some of the programs that could probably be characterized as good examples of technology transfer that came out of some DOE funding?

Mr. **Howard**. Well, yes. The demonstration program, the large cogeneration plant that we built in New Jersey for a vitamin C plant at Hoffman-Laroche, generated for the first—or demonstrated for the first time the technology of the large, slow speed diesel engine which has a vast market potential in this country. And the plant is now operating and is very successful, and it never would have been built had it not been for DOE conservation putting their efforts in.

Mr. **Fuqua**. You think that this and some of the others are effective ways of technology transfer?

Mr. **Howard**. Yes, I do. Yes, I do. I think—I mean, obviously every program that they sponsor is not a success. Many of them involve a lot of risk. But we've certainly seen some successes, and I think that more will come.

Mr. **Fuqua**. Well, the point that you mentioned about the risk, is that—is industry willing to take that risk by themselves?

Mr. **Howard**. Well, you see, we're a company that makes equipment that sells to American industry. Now, for us to invest in a project or a product that has a lot of risk in a long-term is difficult to justify to our stockholders. Now, a whole industry, like the whole steel industry or the whole paper industry, they could play a role like that. But we're an equipment supplier to industry, so we cannot afford to make investments that involve that much risk. And that's why us working with DOE is an ideal combination. And we have successfully commercialized some of these technologies.

Mr. **Fuqua**. So there has been a pay back of the taxpayers' money.

Mr. **Howard**. Yes, absolutely.

Mr. **Fuqua**. And as a taxpayer, you would support that position, too?

Mr. **Howard**. Yes.

Mr. **Fuqua**. Dr. Good, from your perspective from the chemical industry, as well as your other hat as president of the American Chemical Society, how effective do you think that our applicable work in the Department of Energy in transferring technology to the chemical industry has been?

Dr. **Good**. It's a——

Mr. **Fuqua**. And also some ideas for maybe improving that.

Dr. **Good**. Improving it some. The transfer has been reasonably good. It's never as good as you would like, I suspect, and never as good as one would like to envision it. But what has happened in many of the ECUT programs, in particular, in some ways you have to look at the ECUT program a little differently from some of the other programs in the Government.

DOE has the basic energy sciences which is really devoted to doing very fundamental kinds of research. They also have had in the past some out and out demonstration types of programs, which were really looking to see whether or not you could commercialize something. And in some ways, ECUT sort of is the glue between those two extremes; a vehicle, if you like, for technology transfer. And I think in several areas it really has been quite successful.

For example, in the area of membrane technology, which was funded almost exclusively by ECUT for a number of years, you're now beginning to see that technology getting spread around very well. And if you've looked, for example, at some of the mergers and things that have happened recently in some of the small membrane companies that have been purchased by some of the very large chemical companies, you begin to understand that that transfer is taking place very rapidly. And they now understand the value of that, and they're going to put those kinds of membrane technologies in place.

For example, Dow Chemical, you know, bought Film Tech, and there's that kind of thing that's been going on. So the transfer there, I think, is a very clear-cut case where most of all of that membrane work was really funded by ECUT. It really wasn't—it was past the fundamental stage, but it's an interesting problem.

Lots of the materials problems today have the following difficulty, and this is one of the reasons why I think these programs are so important. In the past we've made money in materials by being able to make very large volumes of the same material. And we got our money back on the margin, a small margin on a large volume.

Now, the difficulty is today we know a lot about how to make new materials that will focus on specific problems. And the steel industry is in this bind as well as everybody else. We can now make a specialty material that will solve a particular problem. The difficulty is the industry is having a very difficult time figuring out how to make that material, because now we have to be able to make a significant value added but a small volume.

So we have to be able to understand how to have a generic technology, and how we manufacture a generic technology where, let's say, that I set up to make a polymer material, and I can make—on Monday I make a material that's satisfactory for some of IBM's requirements, on Tuesday I make materials that are adequate for some of the connector suppliers, and so on. In other words, I have to be able to learn how to take those technologies and make money on small volumes, but very important materials.

The whole ECUT program in many ways is designed to help do that. How do you get a generic look at a whole set of materials which are very specific? So although it's not as good as we would like, it's a beginning. The Industrial Research Institute has set up some programs to look at the national laboratories, and there's some very nice stuff going on there now that is getting transmitted.

You and I talked about the aluminide program from Oak Ridge, which is now being looked at very carefully by a number of people, and it looks as if that is going to have some major applications—again in small volume, but from some very important particular air/space applications.

So, in a sense what we're talking about is helping get across that hurdle where we're talking about specialty materials, how to make those, how to manufacture them, how to manufacture them effectively. And I think the technology transfer potential is very, very high in this program.

Mr. **Fuqua**. I have a question for Mr. Leonard here. In the steel initiative, and hoping that we can get that back on track because I think it's a very important initiative——

Mr. **Leonard**. Thank you, Mr. Chairman.

Mr. **Fuqua** [continuing]. Do you anticipate funds from the steel industry would come from the individual companies or through the American Iron & Steel Institute? I think that's the name of——

Mr. **Leonard**. On that particular technology initiative it would be both. There would be some funds from the American Iron & Steel Institute as an organization, and, in addition, support from the individual companies both in terms of technology brought and people working right alongside those of the national laboratories. So it would be truly an industrywide effort.

Mr. **Fuqua**. Would the industry be amenable to—we have, in certain agricultural products and other areas, that based on the tonnage of steel produced that each company involved would contribute a portion, similar to what happens to EPRI and GRI and some of the other organizations?

Mr. **Leonard**. Yes, I understand what you're asking. I would say that there's been a lot of discussion of that concept. The exact form which it would take is not something we can speak unanimously on, but that's certainly a valid question.

Mr. **Fuqua**. Mr. Ritter.

Mr. **Ritter**. Thank you, Mr. Chairman. I want to thank the chairman for inviting me to participate in these hearings. I do not serve as a member of this subcommittee, but I am very, very deeply involved in the area of industrial competitiveness.

And as I listen to the witnesses talk, it hits me that what we're talking about is industrial competitiveness. We're talking about somebody from the chemical and materials field, from the basic industry, from the electronics industry. We're not talking about energy conservation. We're not really talking about saving money on energy. I mean, that has not been a priority for a few years nationally given other priorities.

And right now, with the falling price of oil, it's somewhat less of a priority. So it seems to me, Mr. Chairman, that we have a—we have some basic dichotomy between the mission of an agency given the responsibility to carry out these extraordinarily important programs, and the priorities of the Nation. And I think, you know, until we redesign ourselves and redesign our Federal R&D effort to accommodate more efficiently the area of industrial competitiveness—to package it, promote it, define it, and sell it, and support it—I think we're going to continue to run into these nickel and dime problems.

Now, you know, Dr. Good is talking about materials-by-design that impacts the broad sweep of American industry. I mean, you know, it's really not a DOE priority when you come right down to it. Dr. Leonard is talking about the future of one of the most crucial industries to any industrial power on Earth today and what the foreign competitors are doing. Japan has got a $65 million joint program and we are fighting to retain $7 million. Now they've got it organized a little differently than we do, and, I think, we've got to pay some attention to how they have it organized.

You mentioned, Dr. Leonard, that you, in effect, were betting on our scientists and industry and Government and universities to beat the foreign competition. And I want to bet on them—I'd like to be able to bet on them, too, but we're going to need some money to bet with. And everybody is talking about this joint cooperative effort. It makes good reading and good speaking, but here is a defined program to do just that and we're having such problems keeping it going.

Could you comment on—and I'd like to hear comments from some of the others, too—are we really in the right arena to be dealing with these issues of broad based industrial competitiveness, and can we do better as a nation to organize ourselves more efficiently in this area?

Mr. **Leonard**. Well, Mr. Ritter, first of all, what you said, I think, is a very accurate portrayal of where we are as a nation in the international competitive situation. Is this the right arena? Well, my answer would be this is the best we've got at the moment. I think that this hearing and other efforts along these lines represent an attempt to bring focus to the question you've posed, and to find out how to muster our very extensive resources best to do that in light of all our other priorities.

I think there is an awareness occurring of this issue in other parts of our Government as well as in the congressional side here. I think some of the recent proposals by the administration bear on this. Certainly there have been a number of individual Congress people who have expressed particular concerns. So, I think, we're in the process of developing the necessary consensus and, more importantly, the will to make it a priority item. And this is the context in which I view what we're doing today.

Mr. **Ritter**. Dr. Good.

Dr. **Good**. Yes. Let me make a comment about that. I really am concerned that the—that having some of these programs in conservation is kind of a difficult thing, because with oil going down every day it's kind of hard to get anybody's juices running and talking about conservation.

But, on the other hand, if you look at this, the one—the area that I stressed this morning, if you look at this program, in materials-by-design, for whatever reason, the way we do things, this is the only place in the Government where this program is being focussed as a focussed program to make some progress in that area.

Mr. **Ritter**. You know, and, I think, to that extent, whoever has been leading this charge deserves a lot of commendation. But, you know, this charge may be a very light brigade given the nature of what's going on around this world.

Dr. Howard, Mr. Howard, do you have just a final comment?

Mr. **Howard**. Yes. I just wanted to mention one thing. You've referred to the falling oil prices and natural gas prices. You should keep in mind, I think, that over 40 percent of industry's energy bill is electric. Gas and oil together don't make up that much, and coal is negligible, 15 percent. And the cost of electricity is not going down despite falling oil and gas prices. It's almost totally decoupled from oil and gas prices at this point. It's all capital costs from nuclear and coal-fired plants.

So, that the question of the need to have good energy utilization and——

Mr. **Ritter**. I'm not really questioning—and don't get me wrong—I'm not questioning that need. But I want to thank the chairman——

Mr. **Howard**. From that point of view it's appropriate for DOE.

Mr. **Ritter** [continuing]. And the committee for at least this subcommittee out of many on the Hill, at least, is doing something and spending some money. But I have a feeling that it's really just a tip of the iceberg without the iceberg there. We just have to do more.

Mr. Chairman, thank you very much.

Mr. **Fuqua**. Thank you, Mr. Ritter. I recognize Mr. Walgren, who also has been very, very interested in this project and has been pushing it for some time.

Mr. **Walgren**. Thank you, Mr. Chairman. And I also want to salute the efforts of Congressman Ritter, and I think it's particularly important that we have Members on both sides of the aisle that are very interested in developing this effort. It's helpful in our process here. And I think it is a very important fact because to me it means that when people grapple with the pragmatic problem that we face, there are no ideological differences. And, in fact, there is quite wide agreement on what makes sense to do and the fact that Government can make some constructive contribution in the process.

I hope that we don't get sidetracked by the fact that this is in a conservation budget. Lord knows we have enough military effort in the DOE budget, and we know the purpose is not the energy that's involved but the result of the energy. And certainly the same is true in this and it should fit.

I wanted to ask Dr. Leonard whether, from past experience with the efforts in the National Bureau of Standards in supporting the sensor development program, which as I understand it has come quite far along with both Government and industry working side by side, whether you could say to us that you have confidence that these kinds of progress could be made if Government and industry cooperate in this area, and that the prospect of them not cooperating and going their individual company ways in our economy, given the present structure of things, would clearly doom any future prospect for the steel industry?

Mr. **Leonard**. Well, Congressman Walgren, I share your opinion completely that the prospect of going our separate ways is indeed to doom the industry. It's a long and complicated process that won't happen overnight. But that clearly is the other alternative for us as I see it.

Now, with respect to the National Bureau of Standards programs on sensors, which you've mentioned, that is indeed a model of how cooperation can and should occur, in my opinion. There has been substantial progress made in that particular program that has direct and useful benefit to the steel industry. What we need to do is expand upon those successful models and use them for larger purposes, as we've been discussing today. I think that that could well be something that could be extended into other branches of the Government, in particular DOE.

And I share your view that DOE does many things that are in part energy, but have in fact many other purposes. And so, I think that's exactly what we are advocating be done here today.

Mr. **Walgren**. I get very uneasy when I look at the Japanese educational system and the fact that almost across-the-board their students are brought so much farther along in math and science than ours are. And then when I see that society, having a $65 million effort in this kind of area as a Government contribution and a focussed effort, and we have none, it just seems to be that the handwriting is very much on the wall that if we don't have something similar—it would be one thing to me if we were saying we want to invent this role of Government, but we can look at what's happening out there and see the initiatives they're taking. And if we don't have similar initiatives, focussed initiatives, that we can project actually succeeding in this country, it would seem that we are very much at risk with a most critical industry, as Mr. Ritter has pointed out.

Could you outline the detail that we can project this project having? And by that I mean we're always criticizing Government for going off on some study route and allocating a substantial amount of resources for pretty vague and undefined and not clear and concrete directed effort. That criticism has been made of this effort as well.

Realizing that obviously this has to be developed in the future, can we justifiably go to other Members of Congress and say look, we have a concrete directed plan to succeed in this area?

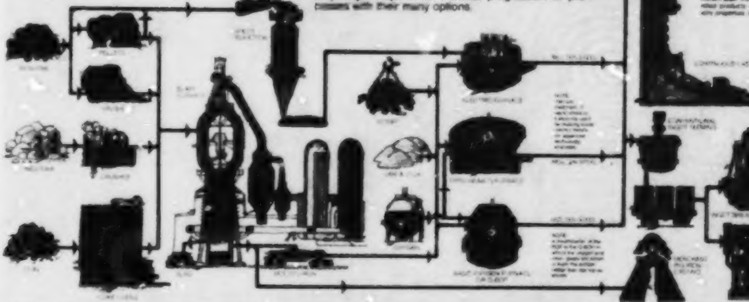
Mr. **Leonard**. My opinion is that we can do that to the extent that it's possible to do it before having actually done the work. This is part of the nature of a technical process that we need to define it and focus it early, as we are discussing here. And yet, until that work is actually done, of course, there is no way to say this is exactly, in fact, what will come out.

Perhaps the best way I can address your concern here, as to whether this is sufficiently focussed, would be to take just a moment to try to convey visually, if I can, what the impact of this whole steel technology initiative might be on the industry. Now, I've previously supplied to Mr. Harvey copies of a chart here which I'll now hold up, and I hope some of you at least have access to, which is an attempt to convey some of the complications that are today involved in making high quality steel.

[The chart referred to follows:]

A flowline of steel

From iron ore, limestone and coal in the earth's crust to space-age steels — this fundamental flowline shows only major steps in an intricate progression of processes with their many options.



some environmental systems parallel to steelmaking

Land reclamation restores mines and quarries to natural state. Tree planting is one method.

Stack cleaners capture dust from [illegible] steelmaking processes, keeping it out of the atmosphere.

Venturi scrubbers [illegible] Recovered solid particles may often be recycled.

Bag houses use cloth bags like big vacuum cleaners to capture dust.

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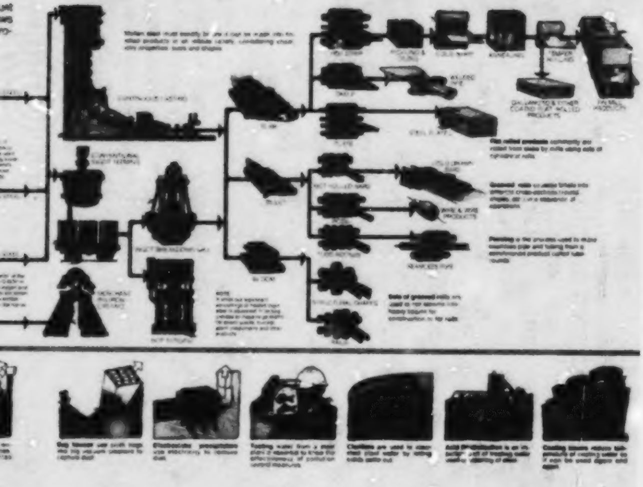
Washington, D.C. 20036

# of steelmaking



Mr. LEONARD. And if any of you can visualize a steelmill, I think we can all share the view of this big rambling structure that runs for miles down a valley somewhere. And what we have to envision is that the technology we are focussing upon here would indeed be radical technology in the sense that it would cause the steelmaking process to be much simpler in terms of the number of steps.

For example, on the chart that we have in front of us, the first steps having to do with making liquid steel are basically three in number, and each of those steps is in turn very complicated, as you I hope can appreciate just by looking at the complexity of the chart. The objective here is to compress those complex multiple steps into one step. And obviously, if successful, that will cause a major decrease in the cost, first, of construction of the plant and, second, of operation of that plant, and, as a part of that operation, in the consumption of energy in the process of that operation.

Similar reasoning applies further on in the so-called finishing ends of the process, here represented by this series of complex lines and rolls of various types. Without getting into the specific details of it, the objective here is the same; namely to reduce the number of steps involved in the process from a large number to a relatively small few, simple, effective steps. So that that is why I said that it takes a focussed crash effort to make this thing work.

Now I, like others here, have expressed and feel the confidence that our scientists and technologists can indeed do that job given the will, given the resources. We simply need to make up our mind to do it.

Mr. WALGREN. Mr. Chairman, if I might have one other question, and that is it's my instinct that we would not be where we are on the sensor technology without the National Bureau of Standards and the industry working together and developing what is a real quantum leap forward in the quality of the materials that we can produce and the quality control in the industry.

Why won't this happen if it's left to industry alone? Was the Government participation in this kind of technological area essential in the sensors area, and is it essential in this area?

Mr. LEONARD. Now that's a very good question. First of all, I believe the National Bureau of Standards' program has been successful because there has been a longstanding tradition of cooperation and interchange in that particular program. And that is what we need to nurture now in a broader scale.

Now, why it has not happened on a broader scale, in my opinion, has to do with U.S. industry focussing on the domestic aspects of competition to the exclusion of international aspects which are now so very much before us.

And in a domestic situation where all competitors are using a similar technology there is not strong incentive for any one competitor, under those narrow circumstances, to invest so heavily and in effect bet the store, and then some, on some new piece of technology.

What we're forced to realize today is that those others across the seas, who chose to take those risks because of differences in their society—and they're very deep, they have to do with cultural as well as financial aspects of those societies—are now forcing us to reevaluate how we address such matters. And again I emphasize that is what we are about here, as I see it, to develop the will to do that. And that means we have to look beyond the short-term payoff computations, which U.S. industry has certainly of necessity done in recent years, and realize that beyond that—all of which is extremely important today—we must make those investments that are long-term in nature if we are to remain a significant international competitor.

Mr. **Walgren**. And if I could only underscore the investments to be made are investments in invention, which is a little different than assembling the capital to produce a product that we know how to do.

Mr. **Leonard**. Quite right, quite right.

Mr. **Walgren**. And in that sense we really have to find different forces to bring together than are presently available in the present economic efforts of a manufacturer.

Mr. **Leonard**. Exactly. And those forces exist in our Nation in great abundance if we can simply manage to figure out how to bring them together effectively and focus them, and some kind of cooperative entity is clearly what we need. And what we're doing is addressing, I think, what is the form of that, what are the pieces that go into it, and how shall it be nurtured and encouraged by all parts of our society, both commercial as well as Government.

Mr. **Walgren**. Well, I'd certainly like to thank the chairman for the open ear that he has given us in this whole area and the sensitivity with which he has received the suggestions that have been made by the private sector and by other Members of Congress and myself. And we do thank you, Mr. Chairman, for the support that you can give to this.

Mr. **Fuqua**. Thank you. Thank you, Mr. Walgren. Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman. Dr. Leonard, if we do not fund the steel initiative program, what will the industry do? How will they respond?

Mr. **Leonard**. We have discussed this at length, and the fact of the matter is that our financial circumstances are such that on our own we have no way to muster a similar program on two counts. No. 1, the simple, fiscal wherewithal is not there today and will not be in the foreseeable future. No. 2, the talents, the personal and human talents, and technical talents needed to do this kind of leapfrog technology also do not exist to any large measure within the individual companies. So we simply must have access to that talent, in this particular case, in the national laboratories, as well as regenerating all the talent we can among ourselves. So we really have no alternatives is what I'm saying.

Mr. **Ritter**. And among the universities as well.

Mr. **Leonard**. Certainly among the universities as well. There are a number who are interested and willing to participate in this kind of activity.

Mr. **Fuqua**. Mr. Packard.

Mr. **Packard**. Yes. It's been noted that in the last—well, in the month of January 1986 that there has been a significant reduction in the importing of steel over a year ago.

If that trend continues, what effect will—will that make it possible for the steel industry to become more involved in a joint venturing aspect or cost sharing arrangement with DOE?

Mr. LEONARD. Certainly we would expect that over the long-term, yes, sir.

Mr. PACKARD. What, in your opinion, has placed the industry, the steel industry, in this position, where they simply have not been able to survive without some Federal assistance in the steel initiative program? What has brought that about, in your judgment?

Mr. LEONARD. Well, it's a long and complicated process going back several decades. But in my opinion, and you understand there are as many opinions as there are people who express them, but my opinion is that this is an inevitable consequence of the large growth mentality that all of our industries have had in the 1960's and 1970's where emphasis on production, with whatever technology was currently available, was absolutely necessary to meet the seemingly insatiable demand.

And under those kind of circumstances, the need to build new technologies for the long-term simply does not get priority attention in any industry. I think we're beginning to see evidences of this in other industries as well as steel. It happens that steel is far along on this cycle of realization, if I can call it that. And I think we're now to the point, as I hope my testimony has conveyed, that we are now ready to address that question.

Mr. PACKARD. Well, that brings me to the next question then. How much, or what percent of your total sales, is devoted to R&D at the present time?

Mr. LEONARD. As an industry, that number is something less than 1 percent of total revenues.

Mr. PACKARD. Will that get you where you just said you have to go?

Mr. LEONARD. In the long run, in my opinion, it will not. I think that the industry indeed has to help itself in the long run. I think part of what we are doing here is creating the will to do just that. The fact of the matter is, however, that this industry is so far behind in terms of need to install currently available technology with whatever additional cash-flow can be generated over the next few years, that we are very much in a catchup situation and will remain there at least for a decade.

And what we are discussing here is an attempt, a genuine attempt on the part of the industry now to take those early actions which will position us such that we will not be in a catchup mode a decade or two from now. So we have two jobs; one, continue the modernization that we're well into today and on which, incidentally, we're spending substantially more cash than is being generated from operation—hence the poor financial circumstance of the industry—and, at the same time, position ourselves for that next round of technology a decade or so hence.

Mr. PACKARD. You indicated that the industry generally is about 1 percent here in this country. How does that compare with foreign steel industry?

Mr. LEONARD. Well, it's somewhat difficult to get exactly comparable numbers. And perhaps the best way to make that comparison is in terms of number of researchers. And the way to convey that is that the total number of research and strongly technical people in the United States industry today is less than that of the single largest Japanese firm in this field.

Mr. **Packard**. Then is it not then projected that with only 1 percent being plowed back into R&D that your job of climbing out of the hole in the next decade or two is literally not going to happen, that you'll get deeper and deeper in the hole as that time proceeds, simply because there's no saw sharpening process going on?

Mr. **Leonard**. Well, that's a very fair question. My opinion is that this is not so much a matter of massive resources on the scale, for instance, of overseas as it is of will and focus and commitment and finally of transfer of the technology. If we can generate the emphasis on that, which we need, the resources will be there. That's my personal opinion.

And I repeat again that my belief is that U.S. scientists and technologists have at least an equal capability to those overseas, and that we can do this if we make our mind up to do so.

Mr. **Packard**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. Fawell.

Mr. **Fawell**. I have no questions, Mr. Chairman.

Mr. **Fuqua**. Mr. Bruce.

Mr. **Bruce**. No questions, Mr. Chairman.

Mr. **Fuqua**. Thank you very much for being here this morning.

Mr. **Ritter**. Mr. Chairman, could I be recognized for one final question?

Mr. **Fuqua**. Yes, sir, hurriedly.

Mr. **Ritter**. Right. This is for Dr. Leonard. Why isn't there—or let's put it another way. We have a bill which makes possible joint R&D ventures that passed the Congress, was signed into law. We know how tough it is for the U.S. steel industry to garner the resources for research and development.

Why is it that there hasn't been a major AISI [American Iron & Steel Institute] effort for a steel technology institute? Why is it that the industry, even when things are not so great, while things are not so great, why haven't they come together to say OK, you know, we're going to plant the seeds in the ground and then the Government is going to be more interested in us and the capital markets will be more interested in us? Why hasn't this happened?

Mr. **Leonard**. Well, first of all, there is a great deal of discussion of that going on right now, as you know. I think the reason it hasn't happened yet is that the interests of the many companies, large and small, specialized and unspecialized, within that institute are such that there is not yet a broad enough constituency there to do that. That's one reason.

Now, there's a second reason, a more difficult one, and that is to do the job we're talking about, an entity must be created which can possess, develop, disseminate, and control the eventual utilization of that technology, first in the United States and over time perhaps worldwide. So by its very nature it's got to be a commercially proprietary entity.

And here we are talking about working together with the Government to do that. That's somewhat of a new thing. And discussions along those lines are taking place now.

Mr. **Ritter**. Well, I would encourage those discussions and I would encourage the formation of a steel technology institute that's industrywide that, in Mr. Packard's words, using the metaphor of a hole, that really starts us climbing out of the hole, and shows that the steel industry itself is willing to be innovative and take innovative steps to get out.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Ritter, and thank you very much for being here this morning.

[Additional questions and answers follow:]

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Telephone 312-391-3331

Mary L. Good
President
Director of Research

March 20, 1986

Hon. Don Fuqua, Chairman
Committee on Science and Technology
Subcommittee on Energy Development
and Applications
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20525

Dear Mr. Chairman:

I sincerely appreciate this opportunity to respond to questions resulting from my testimony on the Department of Energy 1987 Authorization Request for Conservation on March 6, 1986. In preparing my answers, I have attempted to not only directly respond but, in several cases, expound on the philosophy and justification for my proposal on a national thrust for Materials-by-Design. If my responses raise additional questions, I would be happy to prepare answers for them to further supplement the record of the hearing.

Thank you again for your courtesy and hospitality during my testimony and if, in the future, I can assist you in your proceedings in any way, I would be happy to do so.

Sincerely,

Mary L. Good

Mary L. Good

MLG/smk
Enclosure

cc: Dr. Harlan Watson,
Subcommittee Staff

Over 70 years of innovative research

RESPONSES TO QUESTIONS TO DR. MARY L. GOOD BY THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE) FY 1987 Authorization Request for Conservation

March 6, 1986

1. Ques. To what extent have the Signal Research Center and predecessor research facilities worked with the National Laboratories? Please comment on the laboratories involved, the types of programs on which work was done, and your overall impression of these activities.

1. Ans. The Signal Research Center and its predecessor facilities have maintained a regular and continuous relationship with most of the national laboratories. In the past, we have dealt with all of the National Research laboratories at one time or another.

The Signal Research Center currently is involved in the following programs with the national laboratories:

Pittsburgh Energy Technical Center - Coal
Morgantown Energy Tech. Center - Coal
Brookhaven - National Synchrotron Light Source,
    Participation Research Team
Argonne - 6 GeV Synchrotron Advisory Committee
Los Alamos - Materials-by-Design
Oak Ridge - Materials-by-Design Assessment Program
Idaho Falls - Membrane Research Natural Gas Upgrading
Laramie - Shale Oil Recovery

Our overall impression of these activities is that the national laboratories, while attempting to pursue science in the best interests of the nation, have been severely crippled by the government's insistence on its demand for total patent ownership of any inventions accruing from the proprietary use of its facilities and joint or subcontracted research.

2. Ques. What input can a small, growth company in need of advanced materials have to the "materials-by-design" program which you describe? How will the results be made available to all these small companies? Or firms of any size, for that matter?

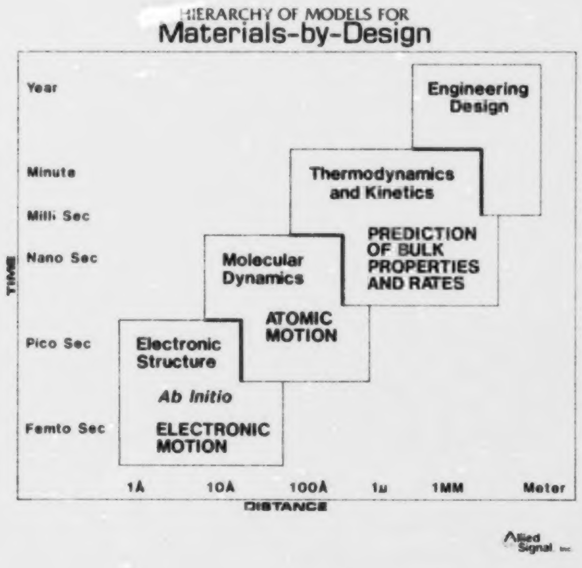
2. Ans. Materials-by-Design is the title of what I consider to be a generic scientific thrust which will aggressively seek to enhance the capability of our nation's scientific community to design materials

from first principles. Any company, individual scientist, or group of scientists can provide input to the Materials-by-Design Program. Once they understand the overall goal - developing the necessary information and tools to advance our nation's capacity to design advanced materials - their own research planning will be impacted in a positive way.

For example, any small growth company with the appropriate talent would be able to take the Materials-by-Design tools (both software and analytical) and apply them to their particular materials needs. Since the generic tools would not be proprietary, any U.S. company would have access to them.

It should be emphasized that the goal of this program is not an individual capability or a specific piece of data. Rather, it is a mechanism for correlating scientific information that will greatly enhance the value of the scientist's time and knowledge. The core of the Materials- by-Design program which I propose should involve an integrating agency or contractor who would be responsible for coordinating the efforts of the scientific community. Working together, academia, industry and government would establish a general rationale and create the software hierarchy necessary to support both theoretical and experimental scientific information (see Figure 1).

Figure 1


HIERARCHY OF MODELS FOR
Materials-by-Design
Year
Minute
Milli Sec
Nano Sec
Pico Sec
Femto Sec
TIME
Engineering Design
Thermodynamics and Kinetics
PREDICTION OF BULK PROPERTIES AND RATES
Molecular Dynamics
ATOMIC MOTION
Electronic Structure
Ab Initio
ELECTRONIC MOTION
1Å
10Å
100Å
1µ
1MM
Meter
DISTANCE

Allied Signal Inc.

I envision joint cost-sharing programs in several thrust areas. The programs can be designed so the results are available to all qualified (non-foreign) companies whose technological position in the economic community can be impacted by this capability. Thus, the participants get early access to these new tools, and the nation's economy as a whole will benefit.

3. Ques. Concern has been expressed by some in the materials sciences community that the basic physics of materials is not well enough understood to support the DOE's Materials by Design program, and that it would better to apply these funds to efforts that are trying to acquire this understanding. How would respond to this concern?

3. Ans. The concerns expressed by the materials science community that the basic physics of materials is not well enough understood to support DOE's Materials-by-Design program is correct if one considers the program as a one time conclusive effort. However, the Materials-by-Design program that I envision is an ongoing effort that takes the information gained from theoretical and experimental research and uses that knowledge to develop operational models which industry can directly apply for materials design. It is specifically because theoretical and experimental research has become so successful in probing the microscopic nature of materials that we now have this opportunity to develop a Materials-by-Design capability.

Materials-by-Design is envisioned as an umbrella program for creating a lattice-work to which information on the basic physics of materials and much additional information can be attached. Once the nation develops this lattice of software and research, we can proceed logically and aggressively to remove the empirical constants from the theoretical equations and advance toward a totally *ab initio* solution to the design of new materials. Directly analogous is the aeronautical industry's effort over the last 50 years through the NACA and NASA to resolve the Navier-Stokes equation for three-dimensional aerodynamic flow without the use of empirical assumptions. It has only been within the last year that articles in the scientific literature have indicated that this most important design equation can now be fully resolved on a computer.

Given the much more complex nature of the Schrödinger (ca. 1926) equation necessary to Materials-by-Design, the proposed national thrust is not capable of immediately resolving it and others in toto. Such a resolution must be gradual and will require the continuous and extended efforts of our scientific community over many years. In the meantime, semi-empirical models are already useful for familiar materials. Each subsequent advance in science will add to our ability in some particular area to more closely approach an *ab initio* solution. This will give us an impressively improved capability to design materials from first principles with a minimum of empirical assumptions. For example, we will soon be able to design process equipment simply by applying our knowledge of what goes on at the atomic level in materials.

4. Ques. The DOE's Energy Conservation Utilization Technologies (ECUT) attempts to bridge the gap between basic research and the more applied conservation programs. Should the Department initiate similar efforts to address this gap in other technology programs, such as in its Solar and Renewable Energy program?

4. Ans. ECUT's attempt to bridge the gap between basic and applied research in DOE's conservation programs should most certainly have a parallel effort in all other government funded research; not just in DOE but in defense, agricultural, medical and every other research arena funded by the government. This approach greatly enhances the likelihood of technology developed with government funds entering our national economy rapidly and profitably. It is, I feel, a successful way to create an environment which will induce American industry to apply advanced technology aggressively, reducing the possibility that foreign nations will use our technology first.

5. Ques. Cooperative Venture R&D Pools have been proposed by the DOE Fossil Energy and Conservation and Renewable Energy programs. In fact, the Fossil Energy FY 1987 budget request includes $12.5 million for this initiative. Might Signal be interested in participating as a partner in these pools?

5. Ans. The Signal Research Center would indeed be interested in participating as a partner in venture R&D pools. However, the Congress must, in some way, insure that private industry could retain, irrevocably, a sufficient degree of exclusivity in the rights to the developed technology to make the investment of the venture capital a rational business decision.

Bethlehem Steel Corporation

BETHLEHEM, PA 18016

JAMES H. LEONARD
VICE PRESIDENT TECHNOLOGY

RECEIVED
MAR 27 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

March 20, 1986

The Honorable Don Fuqua
Chairman, Committee on Science
and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington DC 20515

Dear Mr. Chairman:

In response to your letter of March 10, 1986, attached are answers to the questions raised by Members of the Subcommittee on Energy Development and Applications relative to my March 6, 1986 testimony. The answers include input from all of the steel companies who have been active in the planning of the Steel Industry/Federal Laboratories Initiative and from those companies participating in other DOE-supported projects referred to in the questions.

Thank you for your support of cooperative steel industry R&D. I understand that your Subcommittee approved continued FY 1987 authorization for government support of these projects yesterday.

If you or other Members of the Subcommittee need further elaboration on any of the answers provided herewith, I will be please to provide it.

Sincerely,

JHLeonard
James H. Leonard

Attachment

Proposed Answers to Questions Submitted by Congressman Fuqua on Behalf of the Members of the Subcommittee on Energy Development and Applications of the U.S. House of Representatives' Committee on Science and Technology

Q1 Last year, the steel industry representatives met with National Laboratories and decided that two particular processes could be beneficial if studied. They were the production of liquid steel directly from iron ore, and near-net shape casting. Are there other processes which could be studied with equally beneficial results to the steel industry?

A1 It is important to note that the major thrust of the Steel Industry/Federal Laboratories Initiative is to bring Federal Laboratories' capabilities and resources to bear on steel industry technology needs. Therefore, the choice of processes to be studied was strongly based on the technologies and capabilities available in the Federal Laboratories. Although this can be a significant effort, it in no way approaches the overall needs of the industry for new technology. There are many processes that could be studied with beneficial results to the steel industry, but these are best studied in industry or university laboratories rather than in the Federal Laboratories. In particular, the thin slab casting project currently being funded by DOE at U. S. Steel and Bethlehem Steel laboratories and the DOE/Armco/Westinghouse thin strip casting project are important examples. Both of these projects would be eliminated in the DOE FY '87 budget.

It is also important to note that the terms, "production of liquid steel directly from iron ore" and "near-net shape casting", are generic terms; that is, they are objectives, not processes. In fact, for each of those objectives, there may be several different processes that could accomplish them. For example, the process that the Steel Industry/Federal Laboratories Initiative would work on to try to accomplish "near-net shape casting" is known as "electromagnetic casting" -- a process in which molten steel would be shaped from the force of electromagnetic fields. Other processes for "near-net shape casting" include "moving segmented molds", "single-wheel casting", "twin-wheel casting", etc., all of which are undergoing some level of development outside of the Initiative. Because of the uncertain nature of any research and development activity, it is important that multiple paths be followed in trying to reach these objectives. Thus, given the very high ultimate benefit of being able to achieve an objective such as "near-net shape casting", it is not unreasonable to have several processes under development at the same time.

Finally, the two objectives that are the focal point for the Steel Industry/Federal Laboratories Initiative are not the only objectives worth pursuing to provide beneficial results for the industry. There are many others, a few of which are: direct ironmaking (e.g., the KR-process), continuous steelmaking, continuous cold-rolling, automated processing, etc.

Q2 An important part of the "steel initiative" that was not specifically addressed last year dealt with management. Please give us your thoughts on the method or methods by which these research programs would be managed, some idea of the participants, and possible locations at which work would be performed.

A2 Because the overriding purpose of the Initiative is to provide new technology for economical implementation in the steel industry's manufacturing facilities, it is imperative that the effort be directed toward technical developments that will be relevant to this purpose. Furthermore, since significant parts of the Initiative involve feasibility analysis of new approaches, it is imperative that sufficient flexibility exists in the management structure to permit rapid redeployment of effort to those approaches proving to be of most value, even if different Laboratories are involved. This requires a strong technical management direction from the industry. The industry, as represented by the American Iron and Steel Institute (AISI), has organized an overall Steering Committee and two Program Advisory Committees (one for each of the two Tasks in the program, corresponding to the two objectives discussed above) to provide this strong direction; and intends to assign its own scientists to work in the Federal Laboratories to provide hands-on guidance and facilitate technology transfer from the Laboratories to the industry. The membership on the Steering Committee includes top industry and Laboratory officials. The membership on the Program Advisory Committees includes top technical representatives from the industry and the Laboratories, as well as well-known and highly respected university professors. We feel that this arrangement is a key element in assuring the success of this project.

As discussed in the answer to Question 1, a major element of the Steel Industry/Federal Laboratories Initiative is to bring Federal Laboratories' capabilities and resources to bear on steel industry technology needs. Therefore, it is to be expected that, at least for the feasibility activities comprising the first two years of the program, a significant portion of the work of the Initiative would be carried out in the Federal Laboratories -- primarily, Argonne National Laboratory, Oak Ridge National Laboratory, Idaho National Engineering Laboratory, and National Bureau of Standards. Nevertheless, it is expected that an appropriate amount of the work will be contracted out by the Laboratories to industry laboratories, universities, or research institutes, to cover certain supporting technology developments that can best be accomplished that way.

Q3 You recommended continuation in FY 1987 of the U. S. Steel/Bethlehem Steel thin slab casting project and the Armco/Westinghouse project. How near are these projects to completing their goals, and how much longer will it take to reach these goals. How much funding would you recommend for each in FY 1987?

A3 The U. S. Steel/Bethlehem Steel thin section casting (TSC) project will complete the prepilot-plant stage in 1987 which will result in selection of the preferred TSC process from the multiple-candidate TSC processes which are being assessed experimentally during this prepilot-plant stage. A pilot plant will then be built and operated to further investigate the identified preferred process at a larger scale. The total project is planned for 1989 completion (five-year total project). If this original project mission is maintained, a Department of Energy (DOE) funding increment of $7 million is required for FY '87 (this follows the DOE's original funding plan). We understand that DOE plans to curtail this project and eliminate the pilot-plant phase. U. S. Steel/Bethlehem Steel consider this an undesirable approach and prefer that the original project plan be maintained. If the original project funding plan is not possible, than either a stretched out project or an abbreviated project could be carried out. The objective of a stretched out project would be to accomplish the original project objectives over a longer period of time. An appropriate funding level for a stretched out project in FY '87 is estimated to be $4 million. An abbreviated project could be accommodated provided that sufficient FY '87 funds are appropriated to complete the prepilot plant work. This would then provide the basis for the possibility of carrying the pilot phase forward under a different sponsorship (the "cooperative venture" approach to government funding, for example). U. S. Steel/Bethlehem Steel's technical judgment is that a FY '87 DOE funding increment of $4.3 million is required to bring this abbreviated project to an effective termination. This funding is significantly more than would be derived from the original project plan by subtracting the pilot-plant funding because worst-case planning must be used for the abbreviated project, whereas best-case planning was used for the original project plan as future funds provided the necessary contingency. If the FY '87 DOE funding increment is significantly less than this $4.3 million, then U. S. Steel/Bethlehem Steel technical judgment is that the chances of being able to select the preferred TSC process are low, and all work and funding to date will be wasted, including the industry contribution.

The Westinghouse/Armco project is designed to develop thin strip casting technology for the production of low carbon steel strip suitable for further processing by cold rolling and annealing. The process employs the single wheel planar flow casting technique with electromagnetic shaping of the liquid pool. The project is structured as a three-phase program with the third phase being the design, construction and operation of a pilot scale facility. It is currently in the later stages of Phase II which will result in demonstration of the technical feasibility of the process together with a detailed assessment of the economics and energy conservation potential. Phase II is scheduled to be completed at the end of fiscal year 1986. Phase III is scheduled to commence in fiscal year 1987 and run for a period of five years. The funding requirements for fiscal year 1987 is tentatively estimated as $3.7 million. The primary goal of Phase III is to develop the process for scaling up to a demonstration unit in a steel plant.

Q4 Why do you feel the government should help in new technology development for the steel industry?

A4 The extent to which overseas steel producers now competing in the U.S. market have been subsidized by their governments has been widely discussed and documented. That overseas government support is now being extended more into new technology development, especially in Germany and Japan, as my testimony indicated. The major U.S. steel companies have, at least partly as a consequence of subsidized competition by imports, been forced to reduce their internal support of new technology development to such an extent that it is no longer possible for them to stay abreast of, let alone pull ahead of, overseas state-sponsored development teams with ample government funding. Thus the only possibility for U.S. steel producers to gain any longer-term technology advantage is with government support to "level the (technology) playing field."

Q5 Can you tell us more on what has been developed so far in the U. S. Steel/Bethlehem Steel thin slab casting project?

A5 The thin-section casting project is split into two major phases. The first prepilot-plant phase (which is currently active and scheduled for completion in late 1987) has three critical objectives -- (1) to investigate two fundamentally different approaches to achieving a successful thin-section casting process, (2) to identify the preferred approach, and (3) to generate the data base necessary to justify and allow the design of a large-scale pilot plant utilizing the preferred approach. The subsequent pilot-plant phase (scheduled to start during 1987) would involve the construction and operation of this pilot plant.

In order to meet the objectives of the prepilot-plant phase, much modeling and small-scale phenomena and component testing have already been done culminating in two small experimental casting machines (one at U. S. Steel and one at Bethlehem Steel) which will be used as the critical test-of-concept for each of the two approaches. These two small casting machines will be initially operated in mid-1986. To date, the total project is roughly on schedule and on budget and some promising preliminary results have been obtained. However, the critical experiments (actual casting trials on the two small casting machines) have not yet been attempted.

Q6 Do you have any more thoughts on how a steel industry-government cooperative R&D venture might be organized?

A6 There are many possible organizational arrangements ranging from several small cooperative ventures each working on the development of one or two technologies, perhaps jointly funded by the government under traditional contract procedures, to a single cooperative venture entity involving the development of many technologies cooperatively among several companies. The latter approach meets the intent of DOE as described in its 1987 FY budget request. Rather than traditional government contracts being used, the government's contribution would be in the form of a refundable "grant" no greater than 49% of the total funding. Administration of the program would be by a Board, including representation of participating companies and the government. However, no detailed reports of progress would be necessary as under usual government-industry contracts, thus permitting the technology developed to be maintained for the confidential use of the participants. This is essential if the main purpose of the program - the development and protection of new technology to improve international competitiveness - is to be attained.

Q7 Where did you get your information on government support of new steel technology development by our foreign competitors?

A7 The information on government support of new steel technology development by our foreign competitors was taken from a report prepared for the Department of Energy by a highly respected steel expert based on recent visits with key steel industry personnel overseas.

Q8 Would Bethlehem be willing to commit its proportional share of the $25 million/year industry contribution to the program you've outlined?

A8 Bethlehem would be willing to commit its proportional share of a $25 million/year industry contribution to the program outlined. The program recommended presumes that major domestic steel producers would make commitments sufficient for funding at least 51% of a cooperative, advanced steel technology development effort. That expectation is based on the assumption that promising results from initial stages of the program would convince the major producers to extend their commitments to fund the demonstration of new process technology beyond the pilot plant stage.

Thermo Electron

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27 March 1986

Representative Don Fuqua, Chairman
Committee on Science and Technology
U. S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Fuqua:

Enclosed you will find my answers to your follow-up questions dated March 6, 1986. If you, or members of the Subcommittee or staff members, have any additional questions, please do not hesitate to contact me.

Sincerely,

Robert C Howard
Robert C. Howard
Executive Vice President

RCH/mew

Enclosure

RECEIVED
APR - 7 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Conservation

March 6, 1986

Followup Answers

Mr. Robert C. Howard

QUESTION 1: Please tell us of projects in which your company was involved with DOE that were characterized by good examples of technology transfer. What elements contributed to these successes? How do you measure the effectiveness of technology transfer?

ANSWER: One project which Thermo Electron has been involved in with DOE that characterizes good technology transfer is the Hoffman-LaRoche project described in the testimony. Two additional technology developments that have resulted in improved products are heat pipes and jet impingement heat transfer. These two technologies have made possible improved residential warm air furnaces and ranges. These improvements have included lower first cost appliances with improved thermal efficiency. Improved industrial sheet heater furnaces have also been made possible by applying the jet impingement heat transfer technology. The effectiveness of technology transfer in these instances has been measured by improved production, higher capacity, improved economics of operation and a higher level of quality in the finished product. When the improved products are put into operation, many lessons are learned that usually make possible further improvements in the second generation of products.

QUESTION 2: What technical impediments do you see to prevent combining the conservation and solar buildings R&D programs? If these programs are combined, what administrative savings do you believe could result?

ANSWER: There does not seem to be apparent technical impediments to combining conservation and solar buildings R&D programs. In fact, many efficiencies should result from the combination. The structure of a building and its appliances should be looked at as one energy conservation system rather than developing conservation techniques separately for each.

By combining the two technical areas, cost savings will result from both technical programs and administration. Further cost savings might well result if the Solar Energy Research Institute (SERI) programs were to be administered from the DOE Headquarters rather than the present remote location. Such a change would result in more industrial participation in the solar programs and might well encourage the cooperative venture R&D pools mentioned in Question #4.

QUESTION 3: What government-funded R&D activity is necessary to benefit cogeneration processes?

ANSWER: Necessary government funded R&D activities include research and development in dynamic and static energy conversion devices. The dynamic devices should include development of prime movers with lower cost and higher efficiencies operating on natural gas, dual fuels, biofuels and coal/water slurries. Characteristics needed to make possible such prime movers include increased water jacket temperatures with high temperature liquid or ebullient cooling for greater heat recovery. Lubrication and materials research are needed for solutions to problems created by high temperatures and non-compatability of materials. Cogeneration would be greatly aided by the development of high performance 1-3 kw engines for residential modules. Completely integrated control systems and packages need to be perfected to bring about low installation costs.

Thermionic direct energy conversion devices can be applied to fossil fuel power plants and industrial furnaces to bring about improved overall efficiencies and cogeneration. These are long term programs (five to seven years) and require extensive government funding. Power plant efficiencies could be raised from the present 35 percent to 45 percent. Industrial furnace fuel utilization of 85 percent could be achieved.

QUESTION 4: Cooperative Venture R&D Pools have been proposed by the DOE Fossil Energy and Conservation and Renewable Energy programs. In fact, the the Fossil Energy FY 1987 budget request includes $12.5 million for this initiative. Might Thermo Electron be interested in participating as a partner in these pools?

ANSWER: Thermo Electron has been and is presently involved in several cost sharing R&D programs. This technique works well in near-term situations where the possibility of producing an improved product within two or three years exists. The cooperative venture R&D pool incorporating several companies and the government is quite attractive for long-term (five to seven years) programs. As a technology gets closer to product application, there would be less interest by companies in the R&D pool where they might have to share their production methodologies with competitors. Thermo Electron consequently would perhaps be interested in participating in these pools in the early stages of basic research and technology development but not at a time when the principal activity is applying the developed technology to a specific product.

Mr. **Fuqua**. Our next panel will be Katie Tucker, with the Governor's Energy Office, from Florida; Dr. Lawrence—Lloyd Lawrence, Mechanical Technology, Inc. of Latham, NY; and Mrs. Rosemay Pooler of the New York Public Service Commission, Albany.

Mrs. Tucker, we're delighted to—we're very delighted to have you here. And I might say that Mrs. Tucker and I are from the same little home area in Florida. We're pleased to hear from you next.

STATEMENT OF KATIE D. TUCKER, GOVERNOR'S ENERGY OFFICE, TALLAHASSEE, FL

Mrs. **Tucker**. Thank you, Mr. Chairman and members of the committee, for the opportunity to speak today.

Mr. **Fuqua**. Is the microphone on? There we go.

Mrs. **Tucker**. Now it is. Thank you, Mr. Chairman and members of the committee, for giving me the opportunity to speak with you today on the Energy Extension Service Program and State Energy Conservation Program. I'm glad to know that I have this opportunity to speak for the States, not just for Florida, and get across the message that we believe, as States, represents the position of the real Department of Energy and not the current U.S. Department of Energy in terms of conservation programs.

The administration's 1987 budget proposes to eliminate all funding for the State Energy Conservation Program and the Energy Extension Service, known as SECP and EES. SECP is the mechanism for implementing conservation into transportation, business and industry, and residential sectors in the States. While SECP is extremely important to our national economy, EES is the Federal outreach program that I'm here to discuss with you today because you will decide its future. And now is not the time to leave a legacy. It's the opportune time to springboard conservation technology transfer into the future.

EES is the only Federal program of a uniform national network providing trained experts specifically charged with educating the consumer on technology R&D for managing energy usage. Throughout America, EES is providing daily for the transfer of our most recent technologies. Without outreach programs, our federally funded research would remain available only to those with the time and resources to retrieve it from the volumes of reports prepared from billions of dollars spent in technology development. EES provides information, training, coordination, and a catalytic spark of personal encouragement, the key to obtaining action, within the home, place of work, and Government for energy efficiency and increased energy productivity.

Through EES and State energy conservation programs, modest investments reap massive benefits. These programs get a big job done at a small cost. Let me introduce the conservation and energy extension programs by presenting some statistics which I feel will show the importance of the programs. In addition, these statistics should give the tremendous return on the Federal dollar that has been achieved. In fact, I can show that in terms of the budget reduction Gramm-Rudman Act, the conservation and extension programs should be expanded because of their return on investment rather than dismantled.

Some energy statistics for your consideration. At the national level, since 1979, energy conservation has resulted in a 10-percent increase in per capita energy consumption, a 5-percent decrease in reliance on petroleum, an increase in reliance on wood, solar, and other renewable resources to 5 percent of our total energy consumption. Florida is ahead of this national average even though we're third in size and growing 800 people a day, which you would think would make us need more.

We have reduced per capita energy consumption by 9 percent, reduced reliance on petroleum by 22 percent, saving us 41 million barrels of oil and over $1 billion just in Florida. We've increased our reliance on renewable resources by 6 percent. We've developed an energy efficient code for buildings which makes new construction 40 percent more energy efficient in the State.

There are those that would say that federally funded conservation programs are no longer needed. For example, it's claimed that taxpayers will require local governments to be more energy efficient. In fact, an EES specialist—just to illustrate what happens through the EES program—chaired the Gainesville, FL, Energy Advisory Committee that convinced the city to hire an energy engineer and develop an energy management program. That program has been multiplied across all counties, such that we have in all big counties now an energy engineer. That's also multiplied again, State after State, with EES staff taking the action.

It is claimed the threat of higher utility bills resulting from construction costs will prevent the premature building of new powerplants. In fact, EES and conservation staff nationwide have made the difference in delaying and deferring the construction of powerplants by promoting energy efficiency.

In 1984, 25 percent of our Nation's energy was supplied by conservation. If just one-fourth of these savings are attributed to electricity, the total number of avoided new plants could be as great as 400. The total dollar savings and capital costs alone would then be in the hundreds of billions.

It's claimed legislation alone will require the building of energy efficient structures. In fact, builders cannot effectively obey a law or ordinance if they are unfamiliar with materials and techniques. Inspectors cannot effectively judge poorly constructed structures if they don't understand what they see.

In Florida EES provides training statewide to builders who must meet the new residential energy code requirements by State law, and to the inspectors who are evaluating the completed work. Without this training, we don't feel that our code would meet the 40-percent savings that we are now experiencing.

It's claimed the marketplace alone will force businesses to become more energy efficient. In fact, to illustrate that this would not have happened without help from EES staff, let me point to the Disney area, which is our highest tourist area in the Nation, and what's happening there.

Holiday Inns had experienced a 12-percent increase in energy consumption despite major investments they had made in energy efficient equipment. It was the EES program developed for them that helped them save $164,000 in less than 6 months. That provides a return on investment of 164 to 1. That program is now being implemented in five other States.

It's claimed engineering and construction students graduating from our universities will be trained in more energy efficient practices. In fact, it's EES specialists on the campuses, the University of Florida and other ones all over the Nation, who are helping rewrite the curriculum and teach classes to make that training possible.

I could go on and on. We have much yet to do. Florida's program has assisted the Orlando region of Holiday Inns and we are introducing that program now in three other parts of our State. And the States of California, Nevada, Hawaii, and Arizona are looking into that, as well as Puerto Rico.

I'd like to mention that many States have sent information to us, and I'd like to name some of those because they have especially good programs in the EES, although I have not included those in testimony. And those States, in addition to California, Nevada, Hawaii, Arizona, and Puerto Rico, were Texas, Pennsylvania, Virginia, Alaska, Idaho, Alabama, Colorado, Arkansas, Illinois, Massachusetts, North Carolina, New Hampshire, New Jersey, New Mexico, and New York. They all actively participated in this testimony in providing information to show the return on investment. All of these States have conservation programs that are above the national average according to the data they have sent us, and some as high as 300-to-1 return on investment.

America's fishermen are in dire need of help. We see this in both New England and the other coastal States. The agricultural industry is in dire need. We can see this in the citrus, vegetable, apple, and sugarcane industry, but the problem is national in scope.

Research by the Department of Energy indicated that in 1982 the food processing industry could save 20 percent of their average energy usage with known efficiency technologies and procedures. In a tight market, however, they've been reluctant to invest in these technologies. Again, EES has shown the way. EES has convinced two major food industries to take part in a demonstration project. The success of this $48,000 pilot project has the potential of saving our country's food industry 200 trillion Btu's annually, putting $1 billion back into our U.S. economy.

Let's look at some successes that EES has already demonstrated. You'll see 1 year savings attributable to the program, and then keep in mind that you could multiply that year after year.

In California, six elementary school students were taught to spot potential energy savings around the school during recess, lunch, and after school. They're saving their school a documented $1,000 a month. The program quickly spread to other schools with the local utility picking up the costs. Washington, DC, and New Jersey have also adopted the program, and Wisconsin is considering starting the program statewide. The cost of this EES Program, $100 to implement. The first year return on investment, 120 to 1.

In Minnesota, EES developed the alternative energy engineer program to provide information and technology outreach. As a result, in 1985 alone, 37 schools have been convinced to convert to local renewable energy sources, and are saving $947,000 annually. Return on that investment, 10 to 1.

In Missouri, EES provides a statewide home energy management program that last quarter trained 200 school teachers. These teachers already have trained 4,390 students. The university system contributes a large share of the program funds, but reports it will have to discontinue the program if EES funding of $30,000 is cut. The return on that program, 18 to 1.

These examples illustrate that Americans are interested in managing their energy useage, that investment in energy efficient equipment alone is not enough, that what is needed is education and assistance by an impartial agent to act as a catalyst for action, and that without that catalyst, little will be done. Indeed, much has been started. Much that has been started will cease. The momentum which must be continued to keep attitudes and practices of energy changing can rest with this committee.

When the 1973–74 crisis hit America, we had no State or national energy data and no personnel network in place. We do now with EES and SECP in all States. EES operates in a highly cost effective manner by forming partnerships and using Federal funds for leverage to induce investment of private and local governmental dollars. It teaches the consumer to be an informed energy user. The amount of money saved far exceeds the Federal dollars invested.

The EES program is helping reduce the Federal deficit and the imbalance of trade. Under the real philosophy of the Gramm-Rudman-Hollings Act, a program like this should be expanded rather than dismantled. The proposed cutback in energy conservation programs is especially perplexing when overall defense programs and specific defense related projects within the Energy Department are both slated for sizeable increases.

Energy conservation is one of the most effective defense programs in the entire budget. Why? Because it reduces our vulnerability to disruptions and to political and economic blackmail. It is a fact that conservation is the primary factor contributing to falling energy prices and to the overall improvement in the health of our economy.

Each year billions are spent to develop and maintain the military capability to defend areas of the world containing major reserves of petroleum resources. The administration budget asks for $100 million in military aid for Nicaragua alone. They asked for and got $27 million last year. That's three times the budget for EES. Energy conservation reduces our reliance on OPEC and world energy resources, and therefore reduces our basic vulnerability.

Mr. Chairman, in your letter of February 21, you asked me to address the issue of the oil overcharge funds as well. Specifically, with vast amounts of money having been made available to the States through the $2 billion overcharge Exxon court hearings, why should the Federal Government continue to send money to the States, was your question.

Neither States nor the Federal Government will be receiving the oil overcharge money. In fact, this money is a refund to the people who were overcharged. It's not money that belongs to the State or the Federal Government. Indeed, we are strictly forbidden from using these moneys to purchase equipment, conduct research, replace existing programs, or supervise and administer those programs that come from those funds.

Further, we must spend the money in furthering the five conservation programs Congress specified in the Warner Act, one of which is the EES Program. Just as a State government is not allowed to supplant programs with these moneys, it stands to reason then that the same holds true for the Federal Government.

When the money hits the States, it will need proper administration and supervision. Dismantling the current national mechanism that would provide that supervision and administration, at a time when very large sums will be available for program operation, is not a wise move. The success of your programs lies in the personnel and their experience. We, as a nation, cannot afford to lose 7 years of institutional knowledge and experience.

Additionally, the message that Congress sends to the people should promote a consistent, unified energy conservation program and set an example to all States that energy efficiency will continue to be a high priority. The EES budget and conservation program budget should not be cut as the President is proposing. An equitable, fair approach should be applied across the board.

In closing, when we, as individual citizens, go shopping, we seek the best value for our dollar. We want the maximum return on our investment. DOE data show EES and State energy conservation programs provide a 16 to 1 average return on investment dollars nationwide. Those returns multiply year by year. Energy is basic to everything, and it's efficient use needs to stay in the forefront of congressional priorities.

These programs are truly a best buy for America, a best buy you the Congress can preserve for American taxpayers and for tomorrow's economic well-being. These programs have been cut 75 percent in the last 4 years. EES and conservation programs have taken more than an equitable share of cuts. They're already lean and mean. This is a plea to you to make the first and most important step to go forward again with an energy directive to the States that says, "Yes, we must continue to put in place lifelong energy saving technology and take leadership control of our energy future. Preserve EES and continue our outreach to every energy intensive program area."

This is the positive message that I hope you will send from your august Science and Technology Committee, and thus be permeated into all other House and Senate committees that touch energy conservation issues. Your action will set the tone of what happens in SECP and all other conservation programs because you're first to meet on the issue and you will be first to act.

The Science and Technology Committee should lead energy and commerce into the future. McClure's Senate Energy and Natural Resources Committee last week observed that $1 billion of all overcharged money is slated for the U.S. Treasury. If you do not act and provide legislation, it means we will begin to go backward in building America's energy security. Those moneys belong to the citizens of our country for energy improvements. This is our opportunity to move forward in energy emergency preparedness.

It's the States' position that national conservation leadership begins with you. And I urge you to continue strong support for EES and conservation programs. Thank you, Mr. Chairman and members of the committee, for this opportunity to speak with you on this important issue.

[The prepared statement of Mrs. Tucker follows:]

Testimony of

Katie Tucker

Director

Florida Governor's Energy Office

before the

U. S. House of Representatives

Committee on Science and Technology

March 6, 1986

Mr. Chairman, Members of the Committee:

The Administration's 1987 budget proposes to eliminate all funding for the State Energy Conservation Program and the Energy Extension Service, respectively SECP and EES. SECP is the mechanism for implementing conservation into transportation, business, and residential sectors in the states. While SECP is extremely important to our national economy, EES is the federal outreach program that I am here to discuss today. It is the only federal program providing trained experts specifically charged with educating the consumer on techniques for managing energy usage.

Throughout America, EES is providing the "hands on" leadership and training which makes our conservation technology succeed. (EES literally "plugs in" the "people power" that is essential to the use of our technology.)

EES provides information, training, coordination -- and a catalytic spark of personal encouragement -- the key to obtaining action.

Through EES, and State Energy Conservation Programs, modest investments reap massive benefits. These programs get a big job done, at a small cost.

Let me share with you how energy conservation programs have succeeded in Florida and the nation since 1979:

- o per capita energy consumption has decreased by nine percent; 10.8 percent nationally.

- more importantly, our reliance on petroleum has declined by 22 percent statewide; 5 percent nationally.
- our use of petroleum for electric generation has plummeted by 40 percent; 53 percent nationally.
- we are one of the fastest growing states yet our total energy consumption is growing at only one-third the rate of our population;
- renewable resources provide over six percent of Florida's total energy; 5.3 percent of the nation's energy.
- Florida's Energy Efficiency Code for Building Construction ensures that homes built today are at least 40 percent more energy efficient; over half the states now have Energy Codes.

In 1984 alone, conservation activities have saved Florida the equivalent of more than 41 million barrels of oil, saving over one billion dollars.

There are those who say federally funded conservation programs are no longer needed:

For example, it is claimed taxpayers will require local governments to be more energy efficient.

Fact: An EES specialist chaired the Gainesville, Florida Energy Advisory Committee that convinced the city to hire an energy engineer and develop an energy management program. EES is currently helping train the new energy engineer for Manatee County, because he had difficulty finding training elsewhere. This illustration is repeated in state after state.

It is claimed the threat of higher utility bills resulting from construction costs will prevent the premature building of new power plants.

Fact: EES and conservation staff nationwide have made the difference in delaying and deferring the construction of power plants by promoting energy efficiency. In 1984, 25 percent of our nation's energy was "supplied" by conservation. If just one-fourth of these savings are attributed to electricity, the total number of avoided new plants could be as great as 400. The total dollar savings, therefore, are in the hundreds of billions.

It is claimed legislation alone will require the building of energy efficient structures.

Fact: EES provides training statewide to builders, who must meet Florida's new code,- and to the officials who inspect these new materials and practices. Knowing 40 percent has been saved in Florida homes, and we are growing by 800 people a day, imagine what still remains to be saved in business, industry, and agriculture. Also, conceptualize the number of power plants that have been avoided.

It is claimed the marketplace alone will force businesses to become more energy efficient.

Fact: The Orlando Region of Holiday Inn had experienced a 12 percent increase in energy consumption despite major investments in energy efficient equipment. It was the EES program developed for them that helped them save $164,000 in less than 6 months. The program cost $1,000, for a return on investment of 164:1.

It is claimed engineering and construction students graduating from our universities will be trained in more energy efficient practices.

The fact is: It is EES specialists on the campus of the University of Florida, and on other state university campuses who are helping rewrite the curriculum and teach classes to make this training possible. It was an EES specialist serving as a member of the American Society of Testing and Materials subcommittee who was instrumental in bringing about positive changes in national specifications on energy efficient materials.

And I could go on and on. We have much yet to do. Florida's program that assisted the Orlando Region of Holiday Inn has already been introduced to a number of other hotels in the central Florida area and needs to be supported. We recently hired an agent to expand the EES program to the Miami area. We need to reach the Tampa, Jacksonville, and Pensacola areas. The states of California, Nevada, Hawaii and Arizona have requested the program, and so has Puerto Rico.

America's fishermen are in dire need of help. We see this in both New England and the other coastal states. The agricultural industry is in dire need. We can see this in the citrus and sugar cane industry, but the problem is national in scope. Research by the Department of Energy indicated in 1982 that the food processing industry could save 20 percent of their average energy usage with known efficiency technologies and procedures. In a tight market, however, they have been reluctant to invest in these technologies. Again, EES has shown the way. EES has convinced two major food industries to take part in a demonstration project. The success of this $48,000 pilot project has the potential of saving our country's food industry 200 trillion Btu annually or one billion dollars back into our U. S. economy.

Let's look at some successes EES has already demonstrated. You will see one year savings attributable to the program. Keep in mind that these savings multiply with each additional year.

> In California, six elementary school students were taught to spot potential energy savings around the school during recess, lunch, and after school. They are saving their school a documented $1000 a month. The program quickly spread to other schools with the local utility picking up the costs. Washington, D.C., and New Jersey have also adopted the program and Wisconsin is considering starting the program statewide. The cost of this EES program: $100. The first year return on EES investment: 120:1.
>
> In Minnesota, EES developed the alternative energy engineer program to provide information and technical outreach. As a result, in 1985 alone 37 schools have been convinced to convert to local renewable energy sources and are saving $947,000 annually, two windfarms have been set up to

> harvest wind energy, and a Danish wind blades manufacturer located in the area and created 62 new jobs. The cost of this EES program: $159,000. The first year return on EES investment: 10:1.
>
> Missouri EES provides a statewide Home Energy Management program that last quarter trained 200 school teachers. These teachers already have trained 4,390 students. The University system contributes a large share of the program funds but reports it must discontinue the program if EES funding of $30,000 is cut. The cost of this EES program: $30,000. The first year return on EES investment: An estimated 18:1.

In many communities EES is the catalyst that encourages partnerships between Chambers of Commerce, local utilities, professional organizations, and institutions. With assistance from EES they pool their resources. Individually they do not have the time, information, and resources to form the partnerships on their own. Without a catalyst the programs are not getting started.

> Through the initiative of EES, a partnership was developed between Pacific Gas and

> Electric, the city of Madera, California, and the Chamber of Commerce. A clearinghouse of information was established to provide workshops, energy audits for individual businesses, consultation, and follow-up activities. The first year's savings in electricity amounted to $153,000, 23 percent savings over a comparison group. That comparison group had the same resources available to it, with the exception of EES working to organize, publicize, and educate.

These examples illustrate that Americans are interested in managing their energy usage; that investment in energy-efficient equipment alone is not enough; that what is needed is education, and assistance by an impartial agent to act as a catalyst for action; and that without this catalyst, little will be done. Indeed, much that has been started will cease. The momentum must be continued to keep attitudes and practices of energy use changing.

EES operates in a highly cost-effective manner by forming partnerships and using federal funds for leverage to induce investment of private and local governmental dollars. It teaches the consumer to be an informed energy user. The amount of money saved far exceeds the federal dollars invested. The EES program is helping reduce the federal deficit and the imbalance of trade. Under the philosophy of the Gramm-Rudman-Hollings Act a program like this should be expanded, rather than dismantled.

The proposed cutback in energy conservation programs is especially perplexing when overall defense programs, and specific defense related projects within the Energy Department, are both slated for sizeable increases. Energy conservation is one of the most effective defense programs in the entire budget. Why? Because it reduces our vulnerability to disruptions and to political and economic blackmail. It is a fact that conservation is the primary factor contributing to falling energy prices and to the overall improvement in the health of our economy. Each year billions are spent to develop and maintain the military capability to defend areas of the world containing major reserves of petroleum resources. Energy conservation reduces our reliance on these resources and, therefore, our basic vulnerability.

Mr. Chairman, in your letter of February 21, 1986, you asked me to address the issue of the oil overcharge funds. Specifically, with vast amounts of money having been made available to the states through the oil overcharge court hearings, why should the federal government continue to send money to the states?

Neither state nor federal governments will be receiving oil overcharge money. This money is a refund to the people who were overcharged. It is not money that belongs to the states or federal government. Indeed, we are strictly forbidden to use these monies either for administrative expenses or to replace an existing program. Further, we must spend the money in furthering the five conservation programs Congress established in the Warner Act, one of which is the EES program. Just as state government is not allowed to supplant programs with these monies, it stands to reason that the same holds true for the federal government.

When the money hits the states, it will need proper administration and supervision. Dismantling the current mechanism that would provide that supervision and administration at a time when very large sums will be available for program operation is not a wise move. Replacing the administrative structure with one that can produce as high a return on the dollar as the current EES and SECP programs have demonstrated would be difficult at best. Additionally, the message that Congress sends to the people should promote a consistent, unified energy conservation program and set an example to all states that energy use will continue to be a high priority.

In closing, when we as individual citizens go shopping, we seek the best value for our dollar. We want the maximum return on our investment.

EES, and state energy conservation programs, provide a 16:1 average maximum return on investment dollars. Those returns multiply year by year. Energy is basic to everything, and its efficient use needs to stay in the forefront of Congressional priorities.

These programs are truly a "best buy" for America -- a "best buy" you and the Congress can preserve for American taxpayers, and for tomorrow's economic well-being. These programs have been cut 75 percent in the last four years. EES and conservation programs have taken more than an equitable share of cuts. This is a plea to you to make the first and most important step to go forward again with an energy directive to the states that says: "Yes, we must continue to put in place lifelong energy-saving technology and take leadership control of our energy future. Preserve EES and continue our outreach to every energy intensive program area." This is the positive message that I hope you will send from your august Science and Technology Committee, and thus be permeated into all other House & Senate Committees that touch energy conservation issues.

Mr. **Fuqua**. Thank you very much. Dr. Lawrence.

STATEMENT OF DR. LLOYD R. LAWRENCE, JR., MECHANICAL TECHNOLOGY, INC., LATHAM, NY

Mr. **Lawrence**. Thank you very much, Mr. Chairman. Before I start, I would like to point out that Albany, NY, is well represented on your panel today, and that more than 60 percent of the panel is from that little, small town up in the northern country section of northern New York State. I'd like to have my statement printed in its entirety in the record if I could, Mr. Chairman, and I'll summarize briefly for you today.

Mr. **Fuqua**. Very good. Thank you.

Mr. **Lawrence**. I'm Bob Lawrence. I'm vice president for technology development with MTI, and we're now just under 1,000 people, about 850, and our sales are running a little better than $60 million annually. The focus of our corporation is on industrial quality control equipment and on energy efficient products, services, and research and development.

I'm here today to discuss the need for a strengthened DOE conservation technology budget, especially in the areas of gas-fired heat pumps and industrial R&D. Based on the comments of the Members of this subcommittee earlier, I think that they were quite appropriate to point out that these are really industrial competitiveness issues. And as kind of an introduction to some of the key points in the testimony, I'd like to quote from the President's Commission on Industrial Competitiveness, and their recent report entitled "Global Competition, The New Reality."

> Technology propels our economy forward. Without doubt, it has been our strongest competitive advantage. Innovation has created whole new industries and the renewal of existing ones. State-of-the-art products have commanded premium prices in world markets, and technological advances have spurred productivity gains. Thus, America owes much of its standard of living to U.S. preeminence in technology."

Continuing from that report,

> There is not enough research and development with competitiveness as its goal. The United States currently spends more on research and development than Japan, France, and Germany combined. As a percentage of gross national product, America spends slightly more on R&D than any of our competitors do. But these figures have led to a degree of comfort that is unwarranted.
>
> Roughly half of the total R&D done in the United States is funded by the Federal Government, which spends most of its money (about two-thirds) on defense and space programs. And in those two areas, any commercial spillover is not a prime objective. Thus, when we look at what the United States spends on civilian R&D, areas of innovation from which we can reap the greatest commercial reward, we find outselves behind both Germany and Japan.

Now, I think it's interesting to note how strongly the White House has taken the recommendations in this President's report by looking at the present deferral process and the fact that they are attempting to eradicate all congressional actions on these budgets that would, in fact, enhance our industrial competitiveness.

Along these same lines, Mr. Chairman, I've made a point of pointing out each time I've testified here in the past 8 years what has been happening with our balance of trade deficit. And the important thing here is not so much our annual deficit, which is certainly shocking, but the total accumulated deficit, because we never get this money back. It's an additive process. We lose more each year and that's more from our asset base that goes to other parts of the world.

We now are up to a total of $593.8 billion through 1975 lost from this Nation's asset base through balance of trade deficits. And I just wonder what would be happening to our budget deficit that we're all so concerned about if, in fact, this nearly $600 billions were in our economy and working through it rather than in foreign economies due to these balance of trade deficits.

The other thing I'd like to point out is, as I mentioned 2 years ago in testimony and projected that we would, we have, in fact, now become an international debtor for the first time since 1917. And according to a study by the Institute for International Economics, continuation of current trends could raise our international indebtedness to $1 trillion by the end of 1990, which dwarfs the indebtedness of such countries as Mexico and Brazil.

Clearly these are substantial problems, and they're being recognized now in such Republican publications as "Business Week." I noticed a large article, in fact, in this week's issue on this significant problem. Unfortunately, most things that we see printed point out the problem, but they don't point out too many solutions. And I hope in a small way today, Mr. Chairman, to talk about a couple possible solutions to this.

In the broadest sense, a solution is to enhance our international competitiveness and turn around the balance of trade. This has to be done through a lot of smaller actions, obviously. And I'd like to talk today about one area where a joint effort between Government and industry can, in fact, put us in position to prevent another balance of trade fiasco and, in fact, give us the opportunity for products that could be sold overseas helping our balance of trade.

This particular technology area is gas and oil-fired heat pumps. And I noticed in Mr. Sensenbrenner's opening statement this morning that the oil industry also is supportive if this kind of thing; a high efficiency, oil using technology such as oil-fired heat pumps. And the only difference between a gas and oil-fired one is the burner in the heat pump.

I've included in the testimony some clarification of exactly what a heat pump is. But I think the important thing to the taxpayers and to people paying heating and cooling bills is that a gas or oil-fired heat pump will reduce a gas or oil bill generally by 40 percent on the average. In colder regions of the country it will reduce it by substantially more, and in the warmer regions it will be somewhat less, but still a significant advantage.

Looking at the total potential market for what gas and oil-fired heat pump equipment could be in the United States, DOE estimates there are 50 million homes now heated by gaseous fuel and another 15 million that are heated by either oil or kerosene. So this is the total gross market just in the United States, not talking about either Europe, Japan, or Asia.

If we take that total number of homes and we multiply it by a number like $4,000, which would be a potential installed cost of this equipment, we can see that you rapidly come to a business of $260 billion, assuming that the entire, just the U.S. market could be penetrated.

If we, for the purpose of discussion, reduce this to a more conservative number and help its credibility, we could say half of this market could be potentially penetrated, and now you're talking about a business of $130 billion, which is still substantial. And if you average that over 10 years, again just to use gross numbers—and there are very detailed studies, of course, available on this—to use the gross numbers we would talk about $13 billion per year as a business or an economic unit which is similar to the size of United Technologies Corp.

Now, with something that has this much impact and this much potential business, why is not the private sector investing heavily in this and going after it? And I think that this is kind of a sad testimony on where we stand today in the private sector, Mr. Chairman, but it's a fact that if you can't get your money back—not just see the product in three years, but if you can't get your money back in three years and start seeing a return, it simply does not become a viable private sector investment today.

I had a very disheartening experience, if I could relate to you. Just 2 weeks ago we had an assemblage of 15 bank presidents, presidents of industry, manufacturing industry, investors, at our little company, MTI, for a 2-day meeting to look at some of the technologies that we had for potential private sector investment. We put up a gas-fired heat pump alternative as one of our key items and pointed out that we expected with the proper funding it could be available in a preproduction prototype in three years.

People started looking at their airplane tickets, people started trying to find out who the travel agent was, and we had some real adamant outcries of why did you bring us all the way here to tell us about something that's not available now but we have to wait for 3 years. I think it's really sad, but it's the state of exactly where we are in this country.

To continue some of the details of why the private sector is not heavily into this yet, it's still perceived to be a risky technology. American prototypes are operating in laboratories. We have not been through any field tests or extended operational tests with this kind of equipment yet. The heating industry itself, prior to this, has been a low technology industry, basically based on sheet metal vending. It does not have a high tech base to draw upon to evolve gas or oil-fired heat pump equipment. And private capital, frankly, has too many other nearer term opportunities where it can be spent.

For instance, I think we have seen today a big surge in buying other companies with capital pools. This is a very low risk thing to do because you know exactly how it's going to be reflected on your books the day after that merger or acquisition takes place. And unfortunately that's where the capital is going. It's not going into large potential businesses with some risk attached for the next 3 years and then you get into a product.

Well, in this environment we have evolved through a rather meager DOE program and a GRI program comparable to it, some prototypes that several contractors have. There's about four that are viably operating in laboratory tests cells. And these programs have been structured such that there are very few spare parts, if any, it's not full-time engineered, other things like this. They are not what you would call success oriented R&D programs. But that's where the American technology stands, and we do have some that will provide significant heating and cooling with one button operation.

But the problem that we face right now is that in January of this year our Japanese friends, who had a much stronger effort going on in Japan, delivered to this country 12 gas-fired heat pump units for field tests and market tests in the United States of America. Now, they've looked at these big numbers that I have shown you before, they've also looked at worldwide markets, Europe, Japan, and Southeast Asia, and they realize this is a major opportunity for Japanese business and for the nation of Japan.

The Department of Commerce estimates that some $49 million of just Government money has been put into this area by the Japanese over the past few years. What I would like to point out to you today, though, sir, is that the Japanese heat pump equipment that's coming in is not what we would call strong viable candidates for the American market. It is initial equipment designed to establish the relationships needed to penetrate the market later. They are now going to know the distribution people, the service people, the sales people, who they call on the telephone to get these things into the marketplace. When these are followed by more substantial and better operating equipment later, all of the contacts are in place, and it can just flow into the market.

This can, in fact, be beaten and it can be done with American technology and American manufacturers in a cost shared effort where the Gas Research Institute has testified that it would cost share, a cost shared effort between them and the U.S. Government and, in fact, I think American contractors can be counted on to put in some of their own cash in this over the next 3 years.

It will require a strong program. It needs $20 million a year from all of these entities combined. It needs to be a program aimed at three to four to five prototypes per contractor operating in laboratories where prototypes can be aimed at performance, endurance, reliability, and systems operation. It needs to be the kind of thing that in three years will have enough data and enough operating time so that the private sector can look at it and say yes, this is a viable opportunity for investment, at which time Americans can go after this massive market, and we can then wind up selling equipment overseas rather than having it come here again.

That's basically the gas heat pump situation. Briefly I'd like to point out that the industrial R&D programs at DOE are also extremely important to this area of industrial competitiveness. Those programs are now actually paying back the taxpayer—and I provided a chart in my testimony that shows that the total appropriated amounts, starting back in 1976 and 1977 through the present, are now starting to pay back—in fact, starting in 1985—as these technologies are proceeding into the marketplace, and, in fact, the taxpayers are getting their money back.

In conclusion, the problem that program is facing is that DOE is forcing it into long-term high risk things, whereas the pay back is occurring from the program addressing this 3- to 10-year time period. The 3- to 10-year time period is the one which industry won't address, and the present policy is also moving away from. It's the one where the real technology gains can be made and products are produced.

And my suggestion is that the committee put strong language in this year's bill directing the Department to move the industrial programs back to focussing on that time period, and the same kind of pay backs to the taxpayers can then be realized.

Thank you very much for the opportunity to give this testimony today.

[The prepared statement of Mr. Lawrence follows:]

HEARINGS ON DOE CONSERVATION PROGRAMS

Subcommittee on Energy Development and Applications
Committee on Science and Technology
U.S. House of Representatives

Presented by
Dr. L. R. Lawrence, Jr.
Vice President, Technology Development

March 6, 1986

MECHANICAL TECHNOLOGY INC.

About the Author . . .

Dr. Lloyd R. Lawrence, Jr.

Dr. Lawrence is Vice President for Technology Development, Mechanical Technology Incorporated (MTI). In this position, he is responsible for long-term corporate planning with primary emphasis on Stirling engines, Rankine cycles, heat pumps, and waste heat utilization. He is actively involved in the development of new markets for high-efficiency, high-reliability equipment. Prior to his present position, Dr. Lawrence was Director, Energy Conservation Research with the Gas Research Institute where he was responsible for the Gas Industry's program addressing the improved end use of natural gas. He has been an executive with the Energy Research and Development Administration and with the Air Force Office of Scientific Research. In 1974, he was an Air Force Nominee for America's Ten Outstanding Young Men of the Year. He holds a number of professional memberships and has numerous technical publications.

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Testimony

before the

Subcommittee on Energy Development and Applications

Committee on Science and Technology

U.S. House of Representatives

on the

DOE Conservation Budget

Mr. Chairman and Members of the Subcommittee. I am Dr. L. R. Lawrence, Jr., and I am Vice President for Technology Development with Mechanical Technology Incorporated (MTI). Our firm is a high-technology corporation dedicated to the development and application of high-efficiency energy conversion products and quality control equipment for manufacturing industry. MTI began in 1961 with 7 dedicated engineers, and through innovation, product development, and manufacturing, we have grown to a firm of 850 people and $60 million in annual sales. Slightly over one-half of our revenues come from the sale of products, and the rest is from engineering services and R&D.

I am here today to discuss the need for a strengthened DOE conservation technology budget, especially in the areas of Gas-Fired Heat Pumps and Industrial R&D. These two areas are perfect examples of the types of programs recommended for funding by the President's Commission on Industrial Competitiveness. As many of you are aware, this Commission consisted of high-level people from American manufacturing industry, banking, universities, service entities, and the Administration. In their resulting report entitled "Global Competition, The New Reality," this Commission strongly supported the type of efforts that we are addressing in this hearing today. Quoting from pages 18-19 of this document:

> "Technology propels our economy forward. Without doubt, it has been our strongest competitive advantage. Innovation has created whole new industries and the renewal of existing ones. State-of-the-art products have commanded premium prices in world markets, and technological advances have spurred productivity gains. Thus, America owes much of its standard of living to U.S. preeminence in technology."

And continuing:

> "In order to make technology a continuing competitive advantage for the United States, we need to do three basic things: 1) create a solid foundation of science and technology that is relevant to commercial uses; 2) apply advances in knowledge to commercial products and processes; and 3) protect intellectual property by strengthening patent, copyright, trademark, and trade secret protections. Attaining these goals will require actions on the part of the Federal Government, industry, and our Nation's universities.

> "There is not enough research and development with competitiveness as its goal. The United States currently spends more on research and development (R&D) than Japan, France, and Germany combined. As a percentage of gross national product, America spends slightly more on R&D than any of our competitors do. But these figures have led to a degree of comfort that is unwarranted.
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> "Roughly half of the total R&D done in the United States is funded by the Federal Government, which spends most of its money (about two-thirds) on defense and space programs. And in those two areas, any commercial spillover is not a prime objective. Thus, when we look at what the United States spends on civilian R&D, areas of innovation from which we can reap the greatest commercial reward, we find ourselves behind both Germany and Japan."

Mr. Chairman, the Nation this year is embarked on taking $60-80 billion out of the Federal Budget in response to the Gramm-Rudmann-Hollings Act. As we found in 1981-1983, when that amount of money is summarily removed from Government programs, it is removed from paychecks and plunges the country into a deep recession. The only way to avoid such a recession is to provide a mechanism for jobs; i.e., an increase in available dollars for paychecks from some other resource. We could find those dollars easily, if we could only correct our massive imbalance in trade. At this point, I must laud the efforts of Secretary Baker at the Treasury who is working tirelessly to bring the American currency more into line with foreign currencies, so that we may compete on a better financial basis. But that is not the entire answer. Price is only part of the competitive solution. It must be coupled with more attractive products. And as we have seen graphically in the past ten years, foreign government-industry teams, focusing on commercial items and their evolution, have consistently eroded our competitive position to the point where our balance of trade exceeded $143 billion in 1985. In total, our nation has lost $593.8 billion since 1975 through balance of trade deficits. Imagine the effect on our economy if those funds were still in this country under the control of American consumers. Instead, we have become an international debtor for the first time since 1917.

Our international indebtedness continues to grow, and some business experts predict that in the not-too-distant future, we may become the world's largest international debtor on a scale which will dwarf the indebtedness of such countries as Brazil and Mexico. According to a study by the Institute for International Economics, continuation of current trends could raise our international indebtedness to $1 trillion by the end of 1990. What do we do when we are overcome with such indebtedness and cannot pay back our loans? Threaten the world with dire consequences if they try to collect, using our massive military might which we, in peacetime, have recently assembled?

Mr. Chairman, a piece of military hardware creates jobs only when it is being built. There is no economic benefit associated with it when it is parked on a tarmac. In contrast, a commercial item requires financing, insurance, transportation, distribution, sales, and servicing, and continues in nearly constant use. It is a commercial item, then, which truly adds to our economic health.

With these thoughts in mind, Mr. Chairman, I would like to move on to a situation which has become critical, and which this Committee is in a unique position to do something about. The subject is the Gas-Fired Heat Pump.

GAS FIRED HEAT PUMPS

A gas-fired (or oil-fired) heat pump (the only difference being the burner design) is a device which uses the inherent energy in the atmosphere to provide highly efficient heating (or cooling) to a structure. By using the atmospheric energy properly, the heat that can be delivered to a house will contain more energy content than the amount of energy used to drive the device. In the heat pump itself, a fluid, such as Freon, is circulated in a refrigeration loop. Heat is added to the fluid where it is cold (i.e., outside, in the heating mode) and heat is removed from the fluid where heating is needed (i.e., inside the house). For the benefit of those who are new to this concept, I have included Figures 1 and 2 for clarification.

In the United States today, DOE estimates there are 50 million homes heated by gaseous fuel and another 15 million heated by oil or kerosene. These homes represent the candidate marketplace for gas- and oil-fired heat pumps. Most studies indicate that a well-performing gas- or oil-fired heat pump, with an installed cost of $4000 to $4500, will pay for itself in 3 to 5 years or less in much of the United States. This payback comes from a reduction in fuel use of 40-60% during the heating season. The same piece of equipment has the added advantage of being able to cool from the same fuel supply.

To examine the maximum possible market then (retrofit only), we can take the 50 million gas-fueled homes, add the 15 million oil-fueled homes, and arrive at 65 million homes to be multiplied by the installed cost of $4000. The result is then:

(50 + 15) million x $4000 = $260 billion

I think you will agree, Mr. Chairman, that $260 billion is a large figure, even by Congressional standards. If we modify this figure a bit, for instance, reduce it by one-half to make it more realistic, the number is still $130 billion. If we now average this figure over 10 years (for a gross examination of the situation), we still come up with $13 billion per year, or an economic unit close to the size of United Technologies Corporation.

Why then, with such a large market potential, will not the American private sector "pick up the ball" and fund this technology themselves? The answer is complex, but can be basically broken up into the following parts:

a. The technology is perceived to be risky and will take at least three years to get to preproduction prototypes. Industry is looking for a payback in that time period, not just the start of a business.

b. The heating industry has been generally a low-technology, "metal bending" business and does not have a high technology base to draw on for the evolution of gas heat pump products.

WHAT'S A HEAT PUMP?

- Pumping Heat from a Cold Zone to a Warm Zone

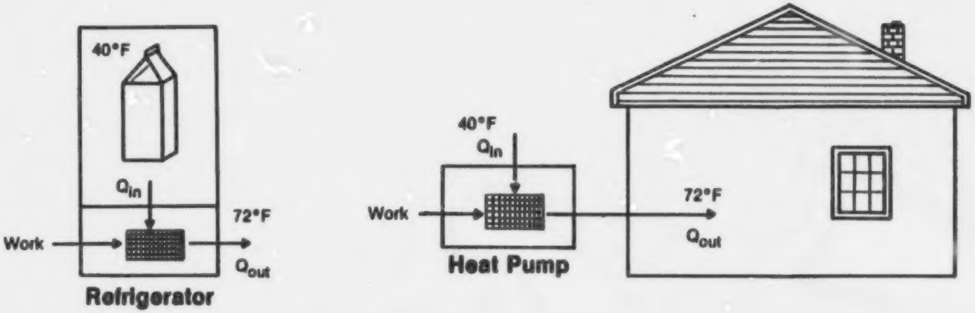
40°F
Q_{in}
72°F
Work
Q_{out}
Refrigerator
40°F
Q_{in}
Work
Heat Pump
72°F
Q_{out}

Figure 1

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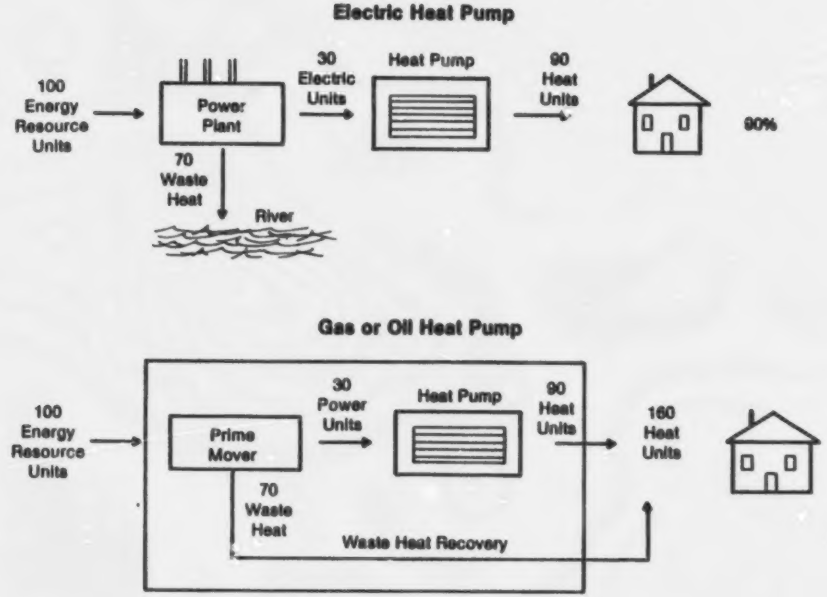
ENERGY RESOURCE USE IN HEAT PUMPS


Electric Heat Pump

Gas or Oil Heat Pump

100
Energy
Resource
Units
Power
Plant
30
Electric
Units
Heat Pump
90
Heat
Units
90%
70
Waste
Heat
River
100
Energy
Resource
Units
Prime
Mover
30
Power
Units
Heat Pump
90
Heat
Units
160
Heat
Units
70
Waste
Heat
Waste Heat Recovery

Figure 2

414

86042

c. Private capital has too many other nearer-term opportunities in which to invest, which can return a profit sooner, such as buying an established business similar to its own. The risk involved with this route is very small.

In this environment, a number of United States contractors have been working on various gas heat pump concepts for more than ten years. These programs have been funded by a meager DOE program ($4 million per year) and a parallel effort by the Gas Research Institute. As a result of this effort, about four contractors have promising prototypes operating in laboratory test cells.

IN JANUARY OF THIS YEAR, THE JAPANESE DELIVERED TWELVE GAS HEAT PUMP UNITS TO THE UNITED STATES TO BEGIN FIELD AND MARKET TESTING.

Once again, the Japanese have found a massive market, focused their resources on it, and are attempting to take it over. The Department of Commerce states that over $49 million of Japanese government funds have been spent during the past few years on gas heat pump developments. This amount has been matched or exceeded by industrial contributions. The 650,000 jobs which are involved in an economic unit of $13 billion per year are of interest to the Japanese.

There is a bright spot in all this. In order to establish their marketing relationships, as well as service and distribution entities, the Japanese have taken the approach of introducing low-performing, high-maintenance gas heat pumps. The American prototypes operating in laboratories can beat the Japanese candidates, keeping the market and jobs for Americans, if only they are allowed to proceed to their full potential. Under the presently available funding, each American contractor has basically one prototype operating in a single test configuration. Spare parts are rare. In the case of our own company, we cannot pay our program manager on the contract, because it would take too much away from the research dollars.

What the program needs is $20 million per year for the next three years. This amount would allow four leading contractors enough money to operate and develop multiple prototypes, with appropriate spare parts. Under such a program, the contractors could have one prototype for each of the key areas of performance, durability, component development, and systems integration. With this type of effort, the units should be at the point, in three years, where the private sector would make the needed investment to take them to market.

The Government does not have to provide the entire $20 million per year. The Gas Research Institute has indicated it might cost share this effort, and some major portion of the $20 million per year may possibly come from them. I would encourage the Subcommittee to explore this with them.

Mr. Chairman, the gas heat pump situation is critical. The nation's future posture in this market and technology needs this Subcommittee's clear and undivided attention. Regardless of the present budget situation, I would hope that the Subcommittee would find this technology to be one of the highest national priority, and treat it accordingly.

INDUSTRIAL PROGRAMS

Mr. Chairman, over the last ten years, I have testified many times in support of DOE's Industrial Conservation programs. Although my corporation has only a very small vested interest in the Industrial programs, the nation has an enormous stake in their outcome.

I have been closely associated with Industrial Conservation programs since 1975, when, as one of the first executives at the Energy Research and Development Administration (ERDA), I watched the Industrial division formed with competent, dedicated people from industry who could readily understand and work with their industrial counterparts, while on the Government side of the equation.

At the inception, under a Republican administration, this division was chartered with the acceleration to market of promising technologies, of high perceived national benefit, which were 3-10 years from the market and had significant economic or technical barriers to overcome. This strategy was excellent in that it addressed the critical 3-10 year time period, which neither the private sector nor the Government normally addresses, and a payback from these efforts can now be measured. The work done in this Division falls exactly in line with the recommendations of the President's Commission on Industrial Competitiveness.

The Energetics Corporation has recently completed a study which examines the impact of the Industrial Conservation program since its inception. Paraphrasing this report, numerous technology improvements have been developed by this Division, jointly with private industry, and have been put into production and use. The technologies include:

Advanced Catalytic Reactors
Cogeneration - Coal-Fired Steam Turbines
Cogeneration - A Slow-Speed Diesel
Coil Coating
Computer-Controlled Ovens
Cupola Stack Air Injection
Dye Bath Reuse
Foam Finishing
Heat Exchange in Drying
High Efficiency Welding
Hyperfiltration - Textiles
Advanced Irrigation Systems
Nitrogen-Methanol Carburization
Organic Rankine Cycle Bottoming Units
Pipe-Cross Reactors
Plating Waste Concentrator
Recuperators
Slot Forge Furnaces

Numbers of units, based on these improved technologies, are now installed and operating across the United States, resulting in a substantial payback to the Government in terms of national benefits. Figure 3 shows that cumulative appropriations since 1975 of $311,145,000 have resulted in cumulative production cost savings to 1985 of $353,000,000. These benefits continue to

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PROGRAM BENEFIT/COST ASPECTS

- Cumulative Appropriations Through Fiscal Year 1985 = $311,145,000
- Cumulative Production Cost Savings to 1985 (23 Successful Technologies) = $353,000,000
- Over 200 R&D Projects Supported to Date

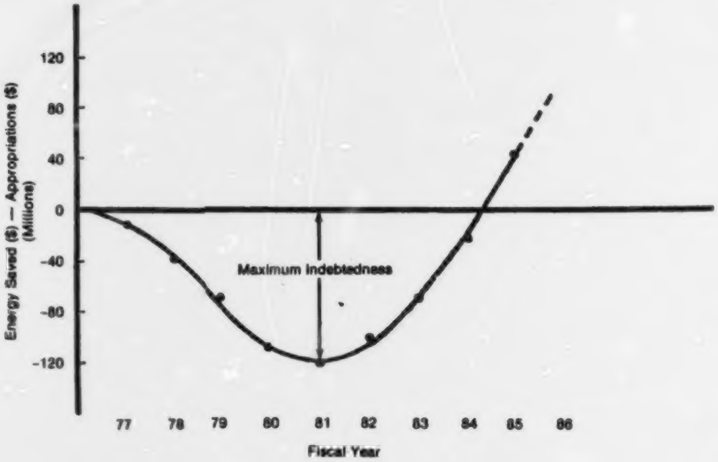

Figure 3

grow geometrically, as the technologies increase their penetration of the marketplace.

In the past few years, direction from administration policy makers has reduced the effectiveness of the R&D dollars spent in this division. Unfortunately, it has been moved away from that critical 3-10 year time frame and has been ordered into the framework of "long-term, high risk," wherein virtually no one can predict a national benefit with any assurance of its occurrence. With our national situation as it is, and the critical nature of our balance of trade, this division must be refocused at those things which it did an outstanding job of accomplishing, i.e., the acceleration and implementation of those higher risk, high potential benefit items which fall into the 3-10 year timeframe.

The recommendation then, Mr. Chairman, is that the Industrial Conservation programs be strongly preserved in the present budget process with strong language directing the Department to focus these programs on those technologies which are highly beneficial in nature, and which can be implemented in the 3-10 year timeframe.

In the letter of invitation to testify, I found wording addressing "an FY 1987 budget consisting of equal reductions in all programs, activities, and projects from appropriated FY 1986 levels by a nominal 15 percent." This Subcommittee has been unique, Mr. Chairman, because for many years, the House DOE Authorization Bill has not had a companion Senate Bill. Even so, your bill has been viewed as the "milestone chart" by the appropriating subcommittees. The reason for this has been the respect those committees have for the careful and deliberative manner in which your bill has been constructed. Clearly, a simple "across-the-board" reduction from FY 1986 levels would not be viewed as a meaningful piece of legislation and would be a dramatic departure from the manner in which this bill has been constructed in the past. In response to your question in the letter, then, my recommendation would be to follow the prudent course of determining appropriate criteria of national benefit by which to judge the various items in the bill (such as jobs, energy conservation, and balance of trade), and judging the line items accordingly, resulting in an allocation of priorites of funding. I have full confidence that you will carry out this process in the deliberative and highly respected manner that has characterized this Subcommittee in the past.

In closing, Mr. Chairman, I would like to quote from an editorial by Morton Zuckerman, Chairman and Editor-in-Chief of U.S. News and World Report. The editorial was published on December 23, 1985. Zuckerman stated:

> "The high technological edge enjoyed by Americans in the 1950s and 1960s has disappeared. Whereas America once had effortless economic superiority, it is now faced with world class competitors who have matched its technological and economic achievements and may well be in the process of moving ahead of it. If trends continue, America's standard of living will fall relative to those of the world's new industrial leaders, such as Japan and Korea - and protectionism guarantees things will get worse because it removes the spur of competition."

And continuing:

> "Any political leader or party wishing to lead America will have to make politically feasible what is economically necessary. We have a positive policy to save our lives. We urgently need one to save our livelihoods."

Mr. Chairman, I thank you for the opportunity to present these thoughts to you and your Subcommittee.

Mr. Fuqua. Thank you very much, Dr. Lawrence. And now, Mrs. Pooler.

STATEMENT OF ROSEMARY POOLER, NEW YORK PUBLIC SERVICE COMMISSION, ALBANY, NY

Mrs. Pooler. Mr. Chairman, thank you for the opportunity to speak to the subcommittee this morning regarding the Department of Energy's proposed fiscal year 1987 conservation budget. I'm Rosemary Pooler. I'm a commissioner with the New York Public Service Commission. Today I'm speaking on behalf of the conservation committee of the National Association of Regulatory Utility Commissioners, the NARUC, on which I serve as chair. And I'm pleased to tell you, Mr. Chairman, that on that committee is Commissioner Katie Nichols of your State, and she has made great contributions. And we've been very interested in learning from her of the great strides that the State of Florida has taken in conservation. It's really a leader in this field.

We're the people on the front line. We're the people who have to pass these rate hikes on. So nothing could be more important to us.

NARUC would like to extend its thanks to the chairman of the committee for the action you took last year in authorizing the least-cost utility planning initiative. NARUC believes this modestly funded technology transfer program will handsomely repay the taxpayers' investments in energy efficiency R&D by accruing substantial savings to America's ratepayers.

As you may have noted from the least-cost hearing held by this committee last September, this initiative will help to identify cost effective measures for cutting in half the $100 billion per year spent on electricity bills for buildings. Given these savings, NARUC was shocked to find DOE eliminating this program in its fiscal year 1987 budget. We strongly urge the committee to oppose this proposal. This is a point I will return to in a moment.

We always anticipated, Mr. Chairman, that this technology transfer was for more than a year. It's asking too much of us, as regulators, and for scientists to have done this in only a year. So we really are appalled.

As you may know from previous testimony before this subcommittee, energy efficiency now provides roughly one-fifth of America's energy services, based on improvements made since the OPEC oil embargo in 1973. These investments in raising the efficiency of millions of buildings, vehicles, appliances, commercial equipment, and manufacturing processes have saved the American economy $150 billion per year, and eliminated the need for 13 million barrels of oil equivalent per day—three times today's foreign oil imports.

Put another way, the United States would be importing four times today's levels if efficiency investments had not occurred. Obviously at that level oil prices would remain high, OPEC would still be controlling prices, and our friends and our trade deficits and inflation rates would be quite severe.

The drop in oil prices, however, does not translate into reduced electricity rates, which have been rising over the past decade. This is due to the fact that oil now constitutes a very small fraction of the overall cost of electricity. Fortunately, as a result of a watershed of scientific and technologocal breakthroughs that have given rise to a wide range of high efficiency technologies, there remains the opportunity to save an additional $150 to $200 billion per year on our Nation's nearly half trillion annual energy bill.

We think though, Mr. Chairman, that if this is only in the laboratory and not on the desks of the people like me, making decisions at the public service commissions throughout this Nation, that it doesn't help the ratepayers. So what we're talking about is technology transfer.

In the last year, I had to vote in the State of New York for a coal conversion project of several hundreds of millions of dollars and a transmission line going through our beautiful Catskill Mountains to get power from Canada to Long Island. I did not have the information available from laboratories when I had to cast those votes. That's what's shocking. We have to get the information from the laboratories, where you and I both know it exists, onto the desks of the regulators at the moment they make the decisions. And that's what your initiative of last year enabled us to begin to start doing.

Well, I begin with this larger context, Mr. Chairman, because I believe the Department of Energy has failed to appreciate these facts about oil in preparing its budget. Although the fiscal year 1987 budget shows an increase of $600 million over fiscal year 1986, we see upward of a 60-percent cut in the conservation R&D budget, and essentially the elimination of the conservation State and local assistance programs.

We do not believe DOE is following either the intent or the letter of the law in suggesting that oil overcharge funds be used to supplant funds for DOE's State and local conservation programs. I echo the words of Mrs. Tucker, and I support her position entirely on this. These funds are for restitution to past victims, not substitution funds for present programs.

As congressional reviews of these programs have shown, the State and local conservation programs are paying for themselves many times over by leveraging private investment into efficiency investments and enabling States and communities to reduce their operating costs. If anything, these programs are grossly underfunded.

The General Accounting Office recently concluded in their review of the Low-Income Weatherization Program that changes in the program have greatly increased the number of eligible recipients, and that at present funding levels it will take upwards of a century to complete the weatherization process.

While the drop in oil prices promises to provide some relief for low-income households, most experts don't expect the oil glut and low prices to sustain itself for the long term. The reason for this is quite straightforward; U.S. oil reserves have been on the decline, the United States is an oil importing nation, and by the 1990's U.S. imports are projected to dramatically increase.

This persistent, long-term vulnerability, due to rising foreign oil imports, underscores the vital role that the Federal Government should continue to play in order to enhance, not undermine, our national security goals. That such efforts are also boons to economic productivity and environmental quality make an overwhelming case for such support.

Obviously in a perfect market of complete information, equal access to capital, the absence of Federal subsidies to competing technologies, and a host of other technical and institutional barriers, there would be little need for the State and local assistance program. But the reality is that there are enormous barriers. And even at the small level that these programs are funded at, they nonetheless serve a vital function in overcoming some of those barriers.

This is especially true of conservation R&D in buildings, industry, and transportation. Unlike the mature energy industries—oil, gas, coal, and nuclear—which have collectively received in excess of $200 billion in Federal energy subsidies over the past half century, and continue to receive roughly $40 billion per year in Federal subsidies, identifying and realizing the investment opportunities in end-use efficiency improvements is still an evolving science and a newly emerging industry.

Yet, Federal conservation R&D has already spurred $68 billion in energy savings from just seven programs at a Federal cost of $19 million. This is a payback to the taxpayer of 4,400 to 1. These and other staggering facts are detailed in a recent "White Paper" prepared by the American Council for an Energy Efficient Economy and the Energy Conservation Coalition. In the interests of time, and with the permission of the chairman, I would like to include the "White Paper" for the record, which elaborates these technologies and the savings.

As this paper notes about high efficiency motors, the United States is losing its competitive edge by not taking advantage of the revolution in high technology advancements that not only promise savings for users, but markets for American business. And in that, I must echo Dr. Lawrence.

We witnessed the decline of the American auto industry over the past two decades, and Japan is poised to repeat the same thing with motors, lighting systems, air-conditioners, refrigerators, heat pumps, and manufacturing equipment. If we are to protect our domestic markets and international trade position, then conservation R&D programs are absolutely essential.

Mr. Chairman, when I speak about air-conditioners, I know whereof I speak. My office address is Albany, but I live in Syracuse, NY, the home of Carrier Air-Conditioning. We've just witnessed a factory making residential air-conditioners move from Syracuse to Brazil. We can't afford that in my hometown. We had 4,000 net job losses in Syracuse last year. What we're saying here, when we're talking about this budget, is, please give us a way not to have that happen.

We are also finding conservation R&D to pay dividends for resolving some of the seemingly intractable environmental problems, such as acid rain and carbon dioxide buildup. As commissioners, who face the unenviable decision of increasing rates or reducing utility stock earnings to help cover the cost of acid rain pollution controls, conservation is emerging as a viable means of reducing emissions while avoiding rate hikes, and while improving utilities' cash earnings.

Much more work remains to be done in this area, but the concept looks so viable that the State of Wisconsin recently incorporated conservation as an integral part of their acid rain reduction program. They found that efficiency technologies could help save $50 million per year in their effort to cut acid rain emissions by 50 percent.

In conclusion, I think it's important to note while the Department of Energy is receding from its support for conservation, both the National Association of Regulatory Utility Commissioners and the National Governors' Association have identified conservation as one of the most important near-term investment opportunities available to the nation. We believe the conservation budget has been cut too severely already, 50 percent over the past 5 years.

In view of these past cuts, and the remaining enormous potential that energy efficiency offers now and for decades to come, we strongly recommend that the conservation budget be frozen at fiscal year 1986 levels. This is an action recently taken by the Senate Energy and Natural Resources Committee.

Thank you, Mr. Chairman. That concludes my testimony.

[The prepared statement of Mrs. Pooler follows:]

STATEMENT OF COMMISSIONER ROSEMARY POOLER
ON BEHALF OF
THE CONSERVATION COMMITTEE OF
THE NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS
BEFORE THE
SUBCOMMITTEE ON ENERGY, DEVELOPMENT & APPLICATIONS
SCIENCE AND TECHNOLOGY COMMITTEE
REGARDING THE DEPARTMENT OF ENERGY'S
FY87 CONSERVATION BUDGET
March 6, 1986

Mr. Chairman, thank you for the opportunity to speak to the Subcommittee this afternoon regarding the Department of Energy's proposed Fiscal Year 1987 Conservation budget. My name is Rosemary Pooler. I am a commissioner with the New York Public Service Commission. Today I am speaking on behalf of the Conservation Committee of the National Association of Regulatory Utility Commissioners (NARUC), on which I serve as chairperson.

NARUC would like to extend its thanks to the Chairman and the Committee for the action you took last year in authorizing the Least-cost Utility Planning Initiative. NARUC believes this modestly funded technology transfer program will handsomely repay the taxpayers' investments in energy efficiency R&D by accruing -- substantial savings to America's ratepayers. As you may have noted from the Least-cost hearing held by this subcommitee last September, this initiative will help to identify cost-effective measures for cutting in half the $100 billion per year spent on electricity bills for buildings. Given these savings, NARUC was shocked to find DOE eliminating this program in its FY87 budget; we strongly urge the Committee to oppose this proposal. This is a point I will return to in a moment.

As you may know from previous testimony before this subcommittee, energy efficiency now provides roughly one-fifth of America's energy services (based on improvements made since the OPEC oil embargo in 1973). These investments in raising the efficiency of millions of buildings, vehicles, appliances, commercial equipment and manufacturing processes have saved the American economy $150 billion per year, and eliminated the need for 13 million barrels of oil equilvalent per day -- three times today's foreign oil imports. Put another way, the U.S. would be importing four times today's levels if efficiency investments had not occurred. Obviously at that level oil prices would remain high, OPEC would still be controlling prices, and our trade deficits and inflation rates would be quite severe.

The drop in oil prices, however, does not translate into reduced electricity rates, which have been rising over the past decade. This is due to the fact that oil now constitutes a very small fraction of the overall cost of electricity. Fortunately, as a result of a watershed of scientific and technological breakthroughs that have given rise to a wide range of high

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efficiency technologies, there remains the opportunity to save an additional $150 to $200 billion per year on our nation's nearly half trillion annual energy bill.

I begin with this larger context, Mr. Chairman, because I believe the Department of Energy has failed to appreciate these facts in preparing its budget. Although the FY87 budget shows an increase of $600 million over FY86, we see upwards of a 60% cut in the conservation R&D budget and essentially the elimination of the conservation state and local assistance programs. We do not believe DOE is following either the intent or the letter of the law in suggesting that oil overcharge funds be used to supplant funds for DOE's state and local conservation programs. These funds are for restitution to past victims, not substitution funds for present programs.

As Congressional reviews of these programs have shown, the state and local conservation programs are paying for themselves many times over by leveraging private investment into efficiency investments and enabling states and communities to reduce their operating costs. If anything, these programs are grossly underfunded. The General Accounting Office recently concluded in their review of the Low-Income Weatherization Program that changes in the program have greatly increased the number of eligible recipients, and that at present funding levels it will take upwards of a century to complete the weatherization process. While the drop in oil prices promises to provide some relief for low-income households, most experts don't expect the oil glut and low prices to sustain itself for the long-term. The reason for this is quite straightforward: U.S. oil reserves have been on the decline, the U.S. is an oil importing nation, and by the 1990s U.S. imports are projected to dramatically increase.

This persistent, long-term vulnerability due to rising foreign oil imports underscores the vital role that the federal government should continue to play in order to enhance, not undermine our national security goals. That such efforts are also boons to economic productivity and environmental quality make an overwhelming case for such support.

Obviously in a perfect market of complete information, equal access to capital, the absence of federal subsidies to competing technologies, and a host of other technical and institutional barriers, there would be little need for the state and local assistance programs. But the reality is that there are enormous barriers and, as small as these programs are funded, they nonetheless serve a vital function in overcoming some of those barriers.

This is especially true of the conservation R&D in buildings, industry and transportation. Unlike the mature energy industries -- oil, gas, coal and nuclear -- which have collectively received in excess of $200 billion in federal energy subsidies over the past half century, and continue to receive roughly $40 billion per year in federal subsidies, identifying and realizing the investment opportunities in end-use efficiency improvements is still an evolving science and a newly emerging industry. Yet, federal conservation R&D has already spurred $68 billion in energy savings from just seven programs, at a federal cost of $19 million. That is a payback to the taxpayer of 4400 to one. These and other staggering facts are detailed in a recent "White Paper" prepared by the American Council for an Energy Efficient Economy and the Energy Conservation Coalition. In the interests of time, and with the permission of the Chairman, I would like to include the White Paper for the record, which elaborates these technologies and the savings.

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We are also finding conservation R&D to pay dividends for resolving some of the seemingly intractable environmental problems such as acid rain and carbon-dioxide build-up. As commissioners who face the unenviable decision of increasing rates or reducing utility stock earnings to help cover the cost of acid rain pollution controls, conservation is emerging as a viable means of reducing emissions while avoiding rate hikes and while improving utilities' cash earnings. Much more work remains to be done in this area, but the concept looks so viable that the state of Wisconsin recently incorporated conservation as an integral part of their acid rain reduction program. They found that efficiency technologies could help save $50 million per year in their effort to cut acid rain emissions by 50%.

In conclusion, I think it is important to note that while the Department of Energy is receding from its support for conservation, both the National Association of Regulatory Utility Commissioners and the National Governors Association have identified conservation as one of the most important near term investment opportunities available to the nation. We believe the conservation budget has been cut too severely already -- 50% over the past five years. In view of these past cuts, and the remaining enormous potential that energy efficiency offers now and for decades to come, we strongly recommend that the conservation budget be frozen at FY86 levels. This is an action recently taken by the Senate Energy and Natural Resources Committee. Thank you Mr. Chairman, that concludes my testimony.

Mr. **Fuqua**. Thank you very much. And at the request of Mrs. Schneider, I'd like to include a statement by Dr. F. William Kirsh, director of the Energy Analysis and Diagnostic Center Program, for the record at this point.

[Statement of Mr. Kirsh appears as an additional statement for the record.]

Mr. **Fuqua**. Mrs. Pooler, are you aware of the recent Federal Register announcement of DOE's least-cost planning study that they've announced for March 12, I think it is?

Mrs. **Pooler**. Yes, I am.

Mr. **Fuqua**. Is your group, the regulatory group, planning to participate in that activity and——

Mrs. **Pooler**. Indeed we are. We're watching very closely how that money is spent, Mr. Chairman. We have an interest in making sure that we get our money's worth in technology transfer.

Mr. **Fuqua**. What do you anticipate the annual growth rate is going to be in your State, on the average, between now and the year 2000?

Mrs. **Pooler**. We're using in our demand forecasts about 1½ half percent.

Mr. **Fuqua**. Per year?

Mrs. **Pooler**. Per year. This is the Northeast and we have excess capacity as well.

Mr. **Fuqua**. Well, you indicated you were shipping or transmitting power from Canada.

Mrs. **Pooler**. We are. We're doing that because not that we don't have the power, but we can't afford to pay for the power that comes from the Shoreham nuclear generating station and Nine Mile II, which will be finished next year. That is, of course, why we don't get any benefit in New York when the price of oil drops. The largest component now, and for the next several years in New York, is the capital costs that went to build $10 billion worth of nuclear powerplants.

And the ratepayers who talk to me say, please, give us a break; get us out from under—and the businesses. Carrier Corp. is going to send another part of their factory from Syracuse out of the country. When Mario Cuomo went to Michigan to try and bring the Saturn plant to New York, not a successful enterprise, but when he went there, the first thing he said to these folks at General Motors is, "you won't have to pay our utility rates. I'll get you cheap power." Well, that's fine when you're trying to bring a plant. But what about all our businesses that are there? We have to do something to help them.

Mr. **Fuqua**. Mrs. Tucker, with the dramatic drop in oil prices that we've seen in recent months, how does that affect the operation to the various State energy offices?

Mrs. **Tucker**. It varies State by State. Florida and California, Arizona, Arkansas, some of the States that have tourism as a key part of their economy, the drop in oil prices helps encourage travel. So it helps in terms of the economy in the short term. Given the fact that we know from our history now that you can't look at anything that short term, this consumption continuing to go up isn't something that the energy offices in the Nation are discouraging because of people have done without for a long time. They are now able to travel places they couldn't before and take advantage of where energy is not as big a part out of their operating budgets.

So, that is, and as was mentioned by Mrs. Pooler, it's not reflected in their utility bills dropping yet, but they can see it at the gas pump, and what's happened on that part. But as far as energy offices go, consumption being up, it's forcing a different look at how can you continue long-range attitudes and how do you put in place things. Conservation, in other words, is not the nicest word. What you have to push is efficiency, that people put into place things that are going to be in place for a long term.

They don't now look at going and buying gas cheaper as an encourager. They also ignore the miles per gallon on their new car that they may replace into. They may be keeping their thermostats higher or lower, depending on cold or hot, knowing that they have in place heat pumps and systems with more efficient appliances, more efficient energy buildings, so that when they do have to cut back, when the new prices come in, that people won't be freezing to death or, you know, having to do totally without because they can't afford it. It's having in place long-term energy equipment and retrofits that will make the difference.

Mr. **Fuqua**. It's my understanding that the States must advise DOE on the Exxon payback disbursals. How much of that and how burdensome is that to the State energy offices, or the DOE monitoring——

Mrs. **Tucker**. Some States do see it as a burden. Florida does not. We look at it that finally we have some money and we have a voice; we can speak with some authority back to DOE instead of with our hat in our hand. So, we're working to build back our partnerships.

And if we can keep the administration, if we can keep——

Mr. **Fuqua**. But what extent is the monitoring that they require?

Mrs. **Tucker**. Very—we have to report back to DOE and to the court on how we plan to spend those moneys and then how we spend them. According to the Warner Act, we do quarterly reporting back then on what we have done with those, if we have the administrative staff. Of course they've recommended zero administrative staff, and they're also recommending now in the 1986 budget that that moneys not be allowed to be used for administration.

In that case, then the oil overcharge moneys in the States will have to—you'll have sort of a play on what is administration, because they'll have to operate it so—for example, my salary would not be one that would be called—I'd be administrative, so they'd have to pick it up in State GR. But staff that are doing the schools and hospitals program, the EES Program, actually doing it, we'll start calling those operational staff and we'll have to take it out of there. So it would be less money back to the people that were overcharged.

Mr. **Fuqua**. Dr. Lawrence, what criteria do you think should be used in trying to determine the funding priorities of, and program emphasis, in the DOE conservation R&D areas?

Mr. **Lawrence**. Well, Mr. Chairman, I think that it's become clear in those programs that their national effectiveness and priority is much greater than just saving energy. Energy savings should still be one of the criteria, but I think that their impact on industrial competitiveness should be certainly one. How much the private sector will play a part in it and its interest needs to be a criteria. How much cost share could be accomplished, and I think I would also look at the programs based on how they fit into this 3- to 10-year time period, which is really a national void.

If you take a look at the broader national budget in all the other departments you find really very, very substantial amounts going from this 10-year time period out. But the 3- to 10-year period is virtually unaddressed except by a few of these programs that are struggling to continue to address it. And I would use that as a key criteria.

Mr. **Fuqua**. You mention about requests for $60 million in Federal funding over a 3-year period for assisting American industry in producing something. In your case you were talking about the heat pump.

What other products—or can you name some products that have been successfully marketed through programs of that type——

Mr. **Lawrence**. OK.

Mr. **Fuqua** [continuing]. That come to mind or——

Mr. **Lawrence**. I think to clarify, Mr. Chairman, I would hope that that $60 million could be picked up by Gas Research Institute as well as the Government and——

Mr. **Fuqua**. In a joint——

Mr. **Lawrence** [continuing]. And some private sector funding. The program that I'm recommending is one that we've seen in many different areas; everything from Army type programs to NASA to the Air Force—that I used to run myself back 10, 15 years ago. And it's the kind of program structured with a set of specifications and development goals and enough cash, and it's structured properly so that you reach those goals.

So it's a classic equipment development program structure of the kind that's been successful time and time again in DOE—or DOD, NASA, and even in private industry where they wanted to go after product development. It's always been that kind of a thing and that's where that structure has come from.

[Additional written response follows:]

In addition to this approach having been successfully employed by DOD, NASA, and other government entities, it was also successfully used to bring the Pulse Combustion Furnace to commercial product status. In 1977, this high efficiency furnace option was available in only one breadboard prototype, similar to the status of American gas heat pump prototypes today. After the basic promise of the technology had been shown in that first prototype, multiple prototypes were built in order to work on various needed aspects of the equipment simultaneously. Cost share from a potential manufacurer was sought and obtained at this point in time, and as the multiple prototypes were developed, showing more and more promise, the percentage of the manufacturer's cost share increased. Finally, when pre-production prototypes had been developed and were ready for field and market testing, the Lennox Corporation took over all subsequent costs.

Similar approaches are now being used in Japan and Europe to evolve advanced equipment to compete with American manufacturers. They have seen the success of the approach in the United States and are emulating it. Japanese gas heat pumps have been developed using a similar philosophy, and at least one Japanese company is approaching Stirling engine development in similar fashion.

In summary, once the point has been reached in the laboratory where a "breadboard" prototype shows promise of achieving the needed product specifications, it is common practice to proceed to multiple prototypes, developed in parallel, to achieve such needed qualities as endurance, performance, component development, and systems integration. If we are to remain internationally competitive, we must do the same.

Mr. **Fuqua**. Thank you all very much for being here this afternoon.

[Additional questions and answers follow:]

STATE OF FLORIDA

OFFICE OF GOVERNOR BOB GRAHAM

March 26, 1986

Honorable Don Fuqua, M.C.
Second Florida District
2269 Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Fuqua: Don

In response to your request of March 10, 1986, I am attaching replies to the two questions posed by members of the subcommittee relative to my testimony on March 6, 1986.

Thank you, Don, for all your assistance.

With warm personal regards,

Katie

Katie D. Tucker
Director
Governor's Energy Office

KDT/acs

Enclosures

1. Please advise the Committee on the use of Energy Extension funds in connection with the State-wide use of Exxon funds. We note your comment on the fact that these Exxon funds may not be used for administrative purposes.

Response

Section 377.704 Florida Statutes, enacted during the 1984 legislative session, provides legislative intent that funds received by the state due to settlements of certain federal litigation relating to petroleum overcharges cannot be expended unless appropriated by the legislature. A petroleum overcharge package currently is being assembled for the forthcoming legislative session, April through May 1986.

The legislature is expected to appropriate $50,000,000 of the oil overcharge amounts already received or to be received (Exxon plus DOE/OHA Consent Order settlements) between the present time and the end of the state's next fiscal year, June 30, 1987. The tentative recommendation to the Legislature is that 12.5 percent of the petroleum overcharge amount be assigned to the state energy conservation program for the residential/commercial economic sector. Of this $6,250,000 amount, 32.0 percent, or $2,000,000, will be assigned to energy extension service types of projects.

We have already received over $4,000,000 in unsolicited proposals competing for energy extension types of projects that fall in the four principal categories of commercial energy efficiency, building efficiency, agricultural efficiency, and interagency cooperation. These projects will be required to be the types that educate small energy users allowing them to make informed decisions based on the latest information available.

If all states assign about 2 percent of only their Exxon Refunds to energy extension service types of projects, and it is believed most will make this level of assignment, then approximately $42,000,000 of the Exxon money will be channeled into this important conservation effort.

Since administrative expenses of the energy extension service program cannot be paid from Exxon funds, administrative costs must be paid from other appropriated sources - local, state, and federal.

2. We have been advised by DOE that return on Energy Extension Service funds is quite large. Your experience in Florida are examples of this payback. How frequently are such benefits obtained in other states?

Response

While preparing for the presentation to your committee Florida contacted a number of States to determine their current return on investment experience. Of those contacted, many reported a quite high return. These were included in our report. The nationwide average is reported to be as high as 16:1. When evaluating the program in these terms several factors should be taken into consideration:

Created as a reaction to the national energy crisis, the EES Program's original emphasis was on quickly educating as many citizens as possible. Evaluations were based on the number of people educated. As the crisis has temporarily eased EES has taken the opportunity to fine tune its operation to include a more sophisticated measurement of actual energy savings attributable to each program. It is those programs with actually demonstrated energy savings, as opposed to calculated energy savings based on workshop participants, that Florida has included in its report. In some programs, such as those that train building inspectors to spot proper energy efficiency techniques and practices, the return may be quite high but difficult to measure.

Substantial emphasis nationwide is currently being placed on initiating partnerships in the public and private sector to specifically provide greater leverage for EES programs. States have been actively sharing information on successful programs to rapidly spread those that bring a high return. Conversely, information is also being shared that prevents duplication of ineffective programs and practices. The next few years will see a rapid expansion of those programs with a significantly high demonstrated return on investment. Also on the horizon will be greater adoption of EES initiated programs by the private sector as their effectiveness is proven in the field. As this occurs, an even greater return will result.

MECHANICAL TECHNOLOGY INC

March 19, 1986

Honorable Don Fuqua
Chairman
Subcommittee on Energy Development and Applications
Committee on Science and Technology
Room B-374 Rayburn Building
House of Representatives
Washington, DC 20515

Dear Mr. Fuqua:

Thank you for your kind letter of March 10, 1986 regarding the March 6 testimony before your Subcommittee. I greatly appreciated the opportunity to testify at that time.

The following are the answers to the questions which you sent to me:

1. It appears that the budget will reduce funds for a number of programs in the foreseeable future. What programs would be involved in which your company is active? Given a reducing total amount of funds, how would you arrange priorities among those projects in which you are involved?

   Answer: Our corporation is funded by both the Conservation and Fossil technology programs. In the Conservation area, we are funded at less than $500,000 per year by both the Industrial Conservation program and the Technology and Consumer Products area. We receive less than $100,000 per year from the ECUT program. We receive less than $100,000 per year from the Fossil Energy programs. In this time of crisis for our nation's industrial competitiveness, I would set my priorities among these by addressing those programs that can make an impact in the three-to-ten-year time period and make these the priority items. The long term areas are adequately covered in many places in the Federal Budget. Therefore, I would place highest priority on the Gas Heat Pump efforts in Technology and Consumer Products, followed by the Industrial Programs. I see little evidence that ECUT will make much of a difference in the near future except in a couple very select areas, such as membranes.

2. In your testimony, you request $60 million of federal funding over a three-year period assisting American industry to produce a marketable product to overcome foreign competition; in this case, a heat pump. What products can you name which have been successfully marketed through this method federal participation?

MECHANICAL TECHNOLOGY INC. 968 ALBANY-SHAKER ROAD LATHAM, NEW YORK 12110 518/785-2211 TWX 710 443 8190

Honorable Don Fuqua, Chairman
Subcommittee on Energy Development and Applications
March 19, 1986
Page 2

Answer: I feel that the $60 million can be cost shared by perhaps as much as 50% from the private sector. In the pseudo-federal arena (Gas Research Institute), products have been successfully developed, such as the Pulse Combustion Furnace, as I outlined in an answer to a previous question. In the federal arena, it has been successfully accomplished in the areas of high efficiency steam turbines, organic Rankine cycle equipment, and it is in the process of being accomplished in the Stirling Engine arena. A program started by ERDA in 1978 has resulted in the high efficiency steam turbine products marketed by Turbonetics Energy Incorporated. Commercial products resulting from this federal program are in place at Georgetown University, Cal Tech, and five other locations. The products are being actively marketed and sold and are the highest efficiency cogeneration turbines available. Similarly, a federal program to capture and transform waste heat has resulted in the sale of two commercial Organic Rankine Cycle (ORC) turbines to Mobil for their Torrance, California, refinery. These ORC units are now commercially available catalog items. A negotiation is now ongoing to sell a number of these to the People's Republic of China. Additionally, the entire TECOGEN line of Thermo-Electron came out of a government program funded through Transportation Conservation, I believe. Finally, we expect the Stirling Engine to become a commercial product through a similar path. The federal program making Stirlings a reality has reached the point where private sector cost share is occurring. The next step is a commercialization activity.

3. Cooperative Venture R&D Pools have been proposed by the DOE Fossil Energy and Conservation and Renewable Energy Programs. In fact, the Fossil Energy FY 1987 budget request includes $12.5 million for this initiative. Might MTI be interested in participating as a partner in these pools?

Answer: MTI is always interested in supporting something innovative which might serve to strengthen our nation's industrial competitiveness. As the concept of these pools evolves and it becomes more clear as to what they will truly be, MTI would be happy to examine them on a case-by-case basis and consider participation. Criteria for participation, from our standpoint, would be much like our criteria for financing internal research and development but with the added aspect of assessing the risk of giving possible competitors some of our technology.

Thank you for the opportunity to respond to these questions.

Sincerely,

Lloyd R. Lawrence, Jr.
Vice President

/mf

STATE OF NEW YORK
PUBLIC SERVICE COMMISSION
ALBANY

ROSEMARY S. POOLER
COMMISSIONER

THREE ROCKEFELLER STATE PLAZA

April 3, 1986

The Honorable Don Fuqua
Chairman, Subcommittee on
Energy Development and Applications
U.S. House of Representatives
Suite 2321, Rayburn House Office Bldg.
Washington, D.C. 20515

Dear Chairman Fuqua:

Enclosed is a response to the follow-up questions to my March 6, 1986 testimony. I appreciate this opportunity to testify before your Subcommittee. Please call on me if you have any further questions.

Sincerely,

Rosemary S. Pooler
Commissioner

RSP/djc
Encl.

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COMMITTEE ON SCIENCE
AND TECHNOLOGY

Commissioner Rosemary Pooler
New York State Public Service Commission
Response to March 10, 1986 Questions
From the Committee on Science and Technology
U.S. House of Representatives

Q1. To what extent do New York law, regulations, and rates encourage or discourage cogeneration projects? What amount of activity in that concept is taking place in New York State now? What appears to be the predominant fuel of choice?

Response: If full avoided cost is less than $.06/KWH, as it is at most times currently because of declining oil prices, it is the policy of the New York State Public Service Commission that utilities pay small power producers the full avoided costs of the electricity they provide. New York State Law requires that utilities pay $.06 per kilowatt hour for power purchased. About 97 megawatts of cogeneration capacity which is tied into utility electric systems is now on line. This is fueled by solid waste fuels, coal and natural gas. The New York State Energy Office expects about 1500 megawatts of additional small power production will be on line by the year 2000; this includes 400 megawatts of cogeneration. The cogeneration projects now planned in New York State include several fuels, including solid waste, coal and natural gas.

Q2. What barriers exist within the utility industry to the adoption of least-cost programs, with special attention to conservation, demand side, and load shaping programs, and what should DOE consider doing to remove or reduce these barriers?

Response: The largest barrier to the adoption of least-cost programs is the lack of established practices for comparing demand side programs with investments in generation, transmission and distribution alternatives. The practices of the industry varies widely across the country and even within states. Often the benefits and costs of demand side programs are expressed in qualitative terms and when quantified are expressed in terms not directly comparable to the benefits and cost attributed to new supply side programs. For example, the relative risks of demand side and supply side planning strategies are often described as crucial differences; yet there are no established risk assessment practices for least-cost planning. Risk assessment is often confused with sensitivity analysis, benefit cost analysis and methods which incorporate explicit consideration of the probability and cost of planning options. There are no standard practices and there has been no significant demonstration of the effectiveness of the risk assessment and other least-cost planning analysis.

The Department of Energy could contribute significantly by funding demonstration studies and research to improve the knowledge and experience base needed to conduct effective least cost programs. The utility industry has the resources, in EPRI and within companies, to contribute to such studies.

DOE also should increase the funding for conservation research. Further, some least-cost planning objectives may be most effectively achieved through federal regulation. For example, appliance efficiency standards may be a more effective way to achieve the benefits of appliance conservation than using many individual utility programs to try to persuade customers to purchase more efficient appliances. Federal studies should examine what programs and regulations should be administered by DOE to achieve least cost planning objectives. DOE probably should have a limited role, but there is a role for DOE which should be designed with careful thought.

Q3. What barriers exist to public utility commissions giving greater attention to the adoption of least-cost planning programs, with special attention to conservation, demand side and load shaping program? What should DOE consider doing to remove or reduce these barriers?

Response: The greatest public utility commission least-cost planning obstacle is the lack of established procedures for evaluating and comparing the resource cost-effectiveness of demand side and supply side options. The analysis of the risks associated with different investment strategies is poorly developed and certainly not well understood at commissions around the country. Public utility commissions generally lack the resources required to develop standard practices for evaluating the cost-effectiveness of alternative energy supply strategies. Substantial resources are necessary to equip regulatory commissions with the tools and the knowledge needed to move least-cost planning programs forward. There is substantial debate over what criteria should be used for evaluating conservation load management strategic marketing programs. For example, the New York State Public Service Commission decided that minimizing the unit cost of electricity should be the primary criterion for judging the cost-effectiveness of utility conservation investments. Progress has been slow, however, on developing a standard framework of analysis, each company analyzes the application of this criteria very differently and none yet examines the risk of alternatives. The debate will only be settled when substantial experience has been developed.

The DOE is in a unique position to advance the development of that experience and knowledge. Such an effort should involve utility industry, the Electric Power Research Institute and public utility commissions that have been working on this issue. This should be a high priority for DOE efforts to advance least-cost planning. Once the practices and procedures are established, least-cost planning should proceed without further federal incentive.

The current DOE least-cost planning initiative is an important first step. We expect this program first to emphasize communicating the lessons of experience to regulators and then developing studies and report which would improve least-cost planning methods. DOE can play an important role by developing an efficient communication channel available to regulators trying to develop effective least-cost planning. DOE should also provide resources otherwise not available to conduct the studies and demonstrations of least-cost planning needed to enhance the state of the art.

Lacking such a federal commitment, individual state regulatory commissions will individually try to develop effective programs. The collective cost to industry, and consumers will be much higher than if DOE exercises an effective leadership.

Q4. What should be the role of DOE in the development of the data bases that can be used in estimating the effect conservation, demand side and load shaping programs? How can any DOE activity in this area be more effectively coordinated with the activity of States, utilities and other organizations?

Response: There is an important role for DOE in the development of data bases that can be used in estimating the effect of these programs. DOE with resources from the Electric Power Research Institute should be financing work, like that started at Lawrence Berkley and Oakridge National Laboratories, which provides an independent assessment of the cost-effectiveness of different methods of achieving demand side and load shaping objectives. The work at the Lawrence Berkley Laboratory to assess the cost-effectiveness of conservation investments is one type of program. The work at Oakridge National Laboratory to assess the cost-effectiveness of program delivery options is another. This work often extends beyond the reach of the utility industry into state/local government and community organizations. Modest DOE resource commitments will have significant benefits. DOE can also play an important information and program coordination role. EPRI appears to be doing an effective job of tracking the activities at the many electric utilities across the country.

There is a need for a similar type of tracking and coordination of the activities of public utility commissions, state energy offices, municipal energy agencies and private for profit conservation service vendors. The recently initiated DOE least-cost planning initiative being developed with the assistance of the Energy Conservation Committee of the National Association of Regulatory Utility Commissioners and regulators across the country is a good first step. That work should be expanded.

Q5. What should be the role of DOE in the development of models or other analytical tools that can be used in estimating the effect conservation, demand side and load shaping programs? How can any DOE activity in this area be more effectively coordinated with the activity of States, utilities and other organizations?

Response: It is important that regulatory agencies and utilities play an important role in deciding what programs should go forward and then overseeing the conduct of those programs. People who have the responsibility to get the job done should have a hand in deciding how the resources are committed. Substantial utility financed work is now underway to develop models and some analytical tools that are needed for effective performance of least-cost planning oversight. DOE resources are needed to transfer the knowledge of about the state of the art to people in the regulatory agencies and to identify the gaps where additional work is needed. For example, an established practice for assessing the comparative risks of demand side and supply side programs is needed. A standard practice which would be accepted by both the industry and the regulators is needed. What is missing at this point is a limited amount of resources needed to bring information that is available to the people who need it and to identify the gaps in the knowledge that need to be filled. Resources of the utilities through the Electric Power Research Institute and local utilities could fund much of the work that remains to be done. DOE contributions would assure that needs of regulators were adequately addressed.

Q6. What should be the role of DOE in the information, education, and technology transfer area to accelerate the adoption by utilities and public service commissions of conservation, demand side and load shaping programs? How can any DOE activity in this area be more effectively coordinated with the activity of States, utilities and other organizations?

Response: The emerging role of DOE now being developed through the least-cost planning initiative is a good model for an appropriate DOE role in the information, education and technology transfer area. This is one of two major initiatives for actions that the DOE should take. The second action that is needed is increased funding of the conservation research programs. Much conservation research can only be carried out by the end users. Because conservation is such a small part of most end use product development, energy conservation will not receive the focused resource commitment that is needed to substantially advance technology development and program delivery. All conservation research need not be funded by the federal government through DOE; some private industries will proceed without federal contributions. There are important sectors, however, where federal government resources are needed to assure progress.

RSP/dc

Mrs. TUCKER. Thank you.

Mrs. POOLER. Thank you for the opportunity, Mr. Chairman.

Mr. FUQUA. Our next panel will be Dr. James W. Patten of Cummins Engineering Co. of Columbus, IN; and Mr. Morton Sherman of the Jim Walter Corp. of St. Petersburg, FL.

Mr. Patten, we'll be delighted to hear from you at this time.

STATEMENT OF JAMES W. PATTEN, CUMMINS ENGINE CO, CUMMINS TECHNICAL CENTER

Mr. PATTEN. Thank you, Mr. Chairman, for inviting me to testify today on the DOE research and development programs related to heavy duty diesel engine technology.

First let me tell you a little bit about who I am and my involvement with Cummins to put things in perspective.

I am Jim Patten. I've been with Cummins for 4 years. I joined Cummins with the objective of transferring technology to the diesel engine business from other advanced technology industries. I now have the responsibility for all of the materials engineering areas at Cummins, and also the manufacturing processes research and development activities. I've also just been asked to develop the Government funded R&D activities at Cummins, so today's discussion is particularly important to me.

Before joining Cummins I was with Batelle's Pacific Northwest Laboratories for about 13 years. I came from the original Hanford Plutonium Weapons Group, which is a rather different background for a person to come from to go into the diesel engine business.

I was personally pretty heavily involved with weapons materials and heat engine materials and also the oxidation protection coatings for cruise missile engines. I had a national lead lab responsibility for DOE at that time for the combustion zone durability programs. We were functioning as a lead lab for DOE so I'm fairly familiar with the internal workings of the Department of Energy.

I was also involved rather heavily with NASA's low gravity space processing activities as a principal investigator and also as a consultant for selection and design of the Skylab equipment, so our activities that involve cooperative efforts between DOE and NASA go back several years with me.

I was asked today to speak briefly to you about Cummins' experience with the DOE/ECUT programs, which are the energy conservation and utilization technology programs, with particular emphasis on a license that we've taken on the nickel aluminide alloy technology developed by Oak Ridge National Lab. In the material that's handed out to you, the Ni_3Al is the denotation for the nickel aluminide system.

I was told that I had an opportunity to comment on other active areas of interest at DOE. In order to provide a basis for your understanding, I'm first going to briefly describe Cummins and Cummins/DOE/Oak Ridge interactions. I'll then describe our interactions with Oak Ridge concerning the nickel aluminide materials. I'll close with some general comments concerning the DOE program on ceramics for heat engines in the transportation energy conservation area and in the ECUT area; on tribology—which is the science of friction, wear, and lubrication—in the ECUT program; and also on advanced engines in the transportation energy conservation area.

Cummins is essentially a single product company manufacturing heavy duty diesel engines and related system components. We're independent and sell much of our product to companies who also manufacture engines for their own use. Our product line is centered on the truck-sized heavy duty diesel engines in the 50 to 500 horsepower range, with a major product line also extending to 2,000 horsepower.

We manufacture about 60 percent of the heavy duty diesel truck engines in North America. We also make over 40 percent of the heavy duty turbochargers in the world through our subsidiary, Holset. Our annual sales are about $2 to $2.5 billion, with about one-third of these sales going overseas. We manufacture in several domestic and overseas locations, but most engineering design is done in our U.S. headquarters in Columbus, IN.

As I mentioned earlier, I have the materials engineering responsibility at Cummins, and I am going to speak as a technologist today rather than as a representative of company policy, philosophy or business strategy.

Mr. FUQUA. Dr. Patten, let me interrupt you for just a moment. We have a roll call vote, and I'm going to have to recess for just a moment to run over and answer that vote, and we'll be right back.

Mr. PATTEN. All right.

Mr. FUQUA. I think this might be a good point to break.

[Recess.]

Mr. FUQUA. Dr. Patten, we'll resume.

Mr. PATTEN. All right. I was just about to describe the interactions between Cummins and Oak Ridge/DOE. Cummins has had close working relationships on a technical level with DOE headquarters and selected DOE laboratories, such as Oak Ridge, for several years. Cummins has not, in general, aggressively pursued DOE funding, even through Cummins has conducted several relatively small DOE funded programs.

We've tended to view DOE as a source of support either to directly conduct research relevant to our business, but beyond our ability to support ourselves, or to fund needed work elsewhere such that the data would be available to us.

Over the past 4 years, the period that I've been at Cummins, we've provided numerous briefings and "White Papers" to DOE describing our views of the technical needs in heavy duty transportation. This information has almost always included full details of our strategic thinking and our internal technical work.

We've asked DOE/Oak Ridge to respect our proprietary information and they've done so. We feel that the insight we've provided has helped DOE to develop relevant and effective programs. And, as an aside, I think that our relationship along these lines has been rather unique. I don't know of a lot of companies that have shared that sort of internal thinking with DOE.

Our thinking has clearly been reflected in open RFP's, many of which we have not responded to, and in actual funded programs. We feel that this relationship has been very open and productive. It's probably more effective than most Government-industry relationships where there's not an extensive flow of funds. We've learned, however, that transfer of information from other R&D centers to Cummins, in a form that can be readily applied, is very slow and difficult.

I believe this problem will always be present to some extent when the engineer developing new technology and the engineer responsible for applying the technology are not the same person. It's a doubly difficult situation when these people work in different organizations. This is the technology transfer problem that we hear quite a bit about. We're making progress in understanding this problem and dealing with it, but we're far from expert. Cummins intends to continue its efforts in this area together with DOE.

One of the benefits that we've realized from our interactions with DOE has been early awareness of the Oak Ridge development of the ductile nickel aluminide materials. Preliminary data indicates that these materials may be useful for advanced diesel engine components because of low cost—there are no strategic materials involved—attractive mechanical properties at the intermediate temperatures in our diesel engines, which would be less than 1,000 degrees centigrade or 1,300 Fahrenheit, and low density relative to traditional gas turbine superalloys.

We've agreed to participate in a unique Government-industry group to exploit this technology. The basic idea of this group involves a cooperative effort between Oak Ridge and several independent industrial companies, each a leader in its own business area. All participants would do work on the nickel aluminide materials systems, and each industrial company would enjoy rights to the results—both results of their own findings and of findings of the other participants—in their own particular business area.

Oak Ridge would realize license fees and royalties which would support further R&D.

If this approach can be made to work, it will clearly represent a strong advantage for U.S. industry. If it works well enough, it could even create a nucleus for a new approach to world competitiveness. Cummins is the first company to commit funds, people, and facilities to this project. In fact, we are currently a net funding source for Oak Ridge National Laboratories.

We are now experiencing or soon will experience a very rapid technology growth in materials, tribology, and engine systems, including combustion. This growth has not been expected by most people involved in the technology, even those who are most expert and most attentive. These developments may be of great business significance to the extent of influencing national competitive positions in the key transportation industries. In many cases, the work and risk of developing the new technology to commercialization is much beyond that which has traditionally been assumed by individual transportation companies.

Cummins feels that the materials area is developing particularly rapidly, with several new materials systems appearing to challenge longstanding concepts of the "art of the possible." The nickel aluminide materials are a good example. There are similar ceramics examples, and the DOE Heat Engine Ceramics Program is well positioned to track ceramics developments as they occur worldwide. The program is well thought out and it's well conducted—or connected, both to the U.S. ceramics industry and to potential users, such as ourselves. The work currently conducted is badly needed and does not duplicate any other R&D activities.

It should be noted, however, that the combined Government and industry supported R&D in ceramics in the United States is clearly inadequate to compete effectively with current efforts in Japan. I would hope, therefore, that funding in this area would increase rather than being reduced. Given budgeting constraints and a continued critical reassessment of priorities, however, the principal challenge will be to respond quickly to major advances in materials or related design findings.

The status of the ECUT Tribology Program is less clear. I'm dismayed that the proposed support for tribological work represents a reduction of 36 percent from the current level. We, at Cummins, recognize that tribological considerations dealing with properties of solid and liquid materials are limiting advanced engine designs. Tribology, therefore, is likely to be the single most important area of investigation for advanced engine systems. Again, tribology is the science of friction, wear, and lubrication. In spite of this, I see a singular lack of tribology R&D effort, focus, and imagination, both nationally and worldwide. I feel strongly that this situation represents a very real opportunity for DOE to assume a leadership role, with an increased effort to understand system needs and conduct or fund an increased amount of highly focussed cross-disciplinary research. We are clearly not in a position where we understand critical friction and wear phenomena, and we clearly do not have materials systems that in any way satisfy the needs of existing advanced diesel engine designs.

As a final comment, I would like to support the DOE programs on combustion in the ECUT activity and advanced engines in the transportation energy conservation area. I personally feel that DOE management of these programs is very proactive in pursuing new technologies that have promise for vehicle application and reduction of our dependence on high quality petroleum. As in the case of the ceramics program, the challenge in the coming 1 to 2 years will be rapid response to major advances in the technology of combustion processes and engine systems.

That concludes my remarks, Mr. Chairman. I'm trying to stay within your 10 minutes.

[The prepared statement of Mr. Patten follows:]

Dr. James W. Patten
Executive Engineer, Materials Engineering
Cummins Engine Company, Inc., Columbus, IN
Testimony to House Subcommittee on Energy Development
  and Application
March 6, 1986

INTRODUCTION

I have been asked to speak briefly to you today about Cummins' experience with DOE/ECUT programs, with particular emphasis on a license that we have taken on Ni_3Al alloy technology developed by ORNL. I was also told that I had an opportunity to comment on other active areas of interest at DOE. In order to provide a basis for your understanding, I will first briefly describe Cummins and Cummins/DOE/ORNL interactions. I will then describe our interactions with ORNL concerning the Ni_3Al materials, and I will close with some general comments concerning the DOE program on ceramics for heat engines (Transportation Energy Conservation and ECUT), tribology (ECUT) and advanced engines (Transportation Energy Conservation).

CUMMINS

Cummins is essentially a single product company, manufacturing heavy duty diesel engines, and related system components. We are independent, and sell much of our product to companies who also manufacture engines for their own use. Our product line is centered on truck-sized heavy duty diesel engines (50 to 500 horsepower) with a major product line also extending to 2000 horsepower.

We manufacture about 60% of the heavy duty truck diesel engines in North America. We also make over 40% of the heavy duty turbochargers in the world. Our annual sales are about 2 to 2.5 billion dollars, with about one-third of these sales going overseas. We manufacture in several domestic and overseas locations, but most engineering design is done in the U.S. in our Columbus, IN headquarters.

I am responsible for all aspects of Materials Engineering for Cummins. I will speak today as a technologist rather than as a representative of company policy, philosophy, or business strategy.

CUMMINS/ORNL/DOE INTERACTIONS

Cummins has had close working relationships, on a technical level with DOE headquarters and selected DOE laboratories (ORNL, for example) for several years. Cummins has not, in general, aggressively pursued DOE funding, even though Cummins has conducted several relatively small DOE funded programs. We have tended to view DOE as a source of support either to directly conduct research relevant to our business (but beyond our own ability to support) or to fund needed work elsewhere such that the data would be available to us. Over the past four years, the period that I have been at Cummins, we have provided numerous briefings and "white papers" to DOE describing our views of technical needs in heavy duty transportation. This information has almost always included full details of our strategic thinking and our internal technical work. We have asked DOE/ORNL to respect our proprietary information, and they have done so. We feel that the insight we have provided has helped DOE to develop relevant and effective programs. Our thinking has clearly been reflected in open RFP's, many of which we have not responded to, and in actual funded programs. We feel that this relationship has been a very open and productive one. It is probably more effective than most government-industry relationships where there is not an extensive flow of funds. We have learned, however, that transfer of information from other R&D Centers to Cummins, in a form that can be readily applied, is very slow and difficult. I believe that this problem will always be present to some extent when the engineer developing new technology and the engineer responsible for applying this technology are not the same person. It is a doubly difficult situation when these people work in different organizations. I have, of course, just described the broad "technology transfer" problem. We are making progress in understanding the problem and dealing with it, but we are far from expert. Cummins intends to continue its efforts in this area together with DOE.

Ni_3Al MATERIALS DEVELOPED BY ORNL

One of the benefits that we have realized from our interactions with DOE has been early awareness of the ORNL development of ductile Ni_3Al materials. Preliminary data indicates that these materials may be useful for advanced diesel engine components because of low cost (no strategic materials), attractive mechanical properties at the intermediate temperatures (less than 1000°C) encountered in diesel engines, and low density relative to traditional gas turbine superalloys. We have agreed to participate in a unique government-industry group to exploit this technology. The basic idea of this group involves a cooperative effort between ORNL and several independent industrial companies, each a leader in its own business area. All participants would do work on Ni_3Al materials systems, and each industrial company would enjoy rights to results (of their own findings and findings of other participants) in their own business area. ORNL would realize license fees and royalties which would support further R&D. If this approach can be made to work, it will clearly represent a strong advantage for U.S. industry. If it works well enough, it could even create a nucleus for a new approach to world competitiveness. Cummins is the first company to commit funds, people, and facilities to this project. In fact, we are currently a net funding source for ORNL.

GENERAL COMMENTS

We are now experiencing or soon will experience a very rapid technology growth in Materials, Tribology, and Engine Systems (including combustion). This growth has not been expected by most people involved in the technology, even those who are most expert and most attentive. These developments may be of great business significance, to the extent of influencing national competitive positions in the key transportation industries. In many cases, the work and risk of developing the new technology to commercialization is much beyond that which has traditionally been assumed by individual transportation companies.

Cummins feels that the materials area is developing particularly rapidly, with several new materials systems appearing to challenge long standing concepts of "the art of the possible." The Ni_3Al materials are a good example. There are similar ceramics examples, and the DOE heat engines ceramics program is well positioned to track ceramics developments, as they occur world-wide. The program is well thought-out and it is well connected both to the U.S. ceramics industry and to potential users. The work currently conducted in badly needed and does not duplicate any other R&D activities.

It should be noted, however, that the combined government and industry supported R&D in ceramics in the U.S. is clearly inadequate to compete effectively with current efforts in Japan. I would hope, therefore, that funding in this area would increase rather than being reduced. Given budgeting constraints and a continued critcal reassessment of priorities, however, the principal challenge will be to respond quickly to major advances in materials or related design findings.

Status of the ECUT tribology program is less clear. I am dismayed that the proposed support for tribological work represents a reduction of 36% from the current level. We at Cummins recognize that tribological considerations dealing with properties of solid and liquid materials are limiting advanced engine designs. Tribology, therefore, is likely to be the single most important area of investigation for advanced engine systems. In spite of this, I see a singular lack of tribology R&D effort, focus, and imagination, both nationally and world-wide. I feel strongly that this situation represents a very real opportunity for DOE to assume a leadership role, with an increased effort to understand system needs and conduct (or fund) an increased amount of highly focused cross-disciplinary research. We are clearly not in a position where we understand critical friction and wear phenomena, and we clearly do not have materials systems that in any way satisfy the needs of existing advanced diesel engine designs.

As a final comment, I would like to support the DOE programs on combustion (ECUT) and advanced engines (Transportation Energy Conservation). I personally feel that DOE management of these programs is very pro-active in pursuing new technologies that have promise for vehicle application and reduction of our dependence on high quality petroleum. As in the case of the ceramics program, the challenge in the coming 1-2 years will be rapid response to major advances in the technology of combustion processes and engine systems.

Mr. **Fuqua**. Thank you very much, Dr. Patten. Mr. Sherman.

STATEMENT OF MORTON SHERMAN, JIM WALTER CORP., ST. PETERSBURG, FL

Mr. **Sherman**. Thank you, Mr. Chairman. Good morning, ladies and gentlemen. I appreciate the chairman's Florida heritage and I greet you as a fellow Floridian. I've heard quite a bit of talk about Albany here today.

I very much appreciate this opportunity and invitation to speak before you today in support of continuing an effective level of research on energy conservation technologies, via the Department of Energy's Building Thermal Insulation Program. While I have intentionally kept my remarks brief, because of the limited time available today, I would like to voice a strong second to Dr. Good's comments earlier this morning regarding DOE's various materials-by-design programs, and Dr. Leonard's and Dr. Howard's comments regarding cooperative research programs. I hope I can elaborate a little bit in the rest of my discussion. All of this is available in a prepared statement.

Having been involved in private sector thermal insulation research and development for over 30 years, I can well appreciate the positive effects of DOE programs on this industry and the energy conservation methods encouraged and put into everyday use as a result of its advocacy.

Although not personally familiar with all the details of the President's proposed fiscal 1987 budget, it is my understanding that one, energy conservation research R&D, would be cut by 60 percent after a nearly 50 percent reduction since fiscal 1980; second, although the Department of Energy recommended a relatively small $1 million budget for the building materials research task, the President's budget does not fund this important program. I believe this would be a tragic mistake and should not be acceptable to this committee.

I believe there is unanimous agreement that Federal budget realities require a very careful and considered review and adjustment of our spending priorities. However, the elimination of the building materials research task at a time when its efforts, already proven successful and highly cost effective, are being directed toward more public sector/private sector cooperative research programs, would be a wasteful stupidity. Current programs directed to develop thermal insulation technologies many times more efficient than today's commoditiy products would be halted before completion.

Applications development to accelerate the adoption of advanced energy conservation into conventional design practice would return to the snail's pace of the 1970's, when cheaper energy costs motivated inefficient methods and energy waste in construction as justifiable.

We should not ignore, Mr. Chairman, the very expensive lessons learned since 1973; it costs more to catch up than to maintain an ongoing effort in R&D for energy conservation. We should keep in mind, Mr. Chairman, those panic responses generated by the enormous economic impact of energy cost escalation and compounded by inefficient use technologies and intensive demand.

Today's plummeting petroleum prices are the artificial result of manipulated OPEC oil production levels. A nation and economy once more seduced into energy waste and inefficiency lassitude could just as rapidly be hit by another round of oil price increases after OPEC's objectives have been reached.

As an aside, Mr. Chairman, Smith Barney will estimate in a publication to come out within a week that the prices will regain to the 20's per barrel in 3 to 6 months. So it could be a very short heaven for us all.

If this lesson has been learned, we cannot allow productive research and development in building materials technologies to stop. As demonstrated by the proven success of our energy conservation R&D efforts since 1977, our research and development must be a sustained effort to achieve results with cost effectiveness. Crash programs are not the way to go. Specialized personnel and facilities, paid for, assembled, and active, have a very low disposition value on termination, and excessive funding and time is required to reassemble them when the need returns.

I have been involved with the private sector R&D in foam plastic thermal insulation since 1967. Our company's proprietary product development efforts were helped, not hindered, by federally funded R&D activity on these highly efficient thermal insulations during the early days of the aerospace program. I think you're familiar with some of that effort.

It helped to put our products in place to be available for enhanced use and broader commercialization at the initiation of the 1970's energy crisis. Current building materials task efforts, in much the same way, can continue current work on advanced insulation materials and systems so as to have them in place and available when that 1990 oil crisis hits us all.

The Department of Energy has defined a role for Federal research and development in those areas where the incentives for, and the availability of, private investment are severely limited or nonexistent, providing options for private investment and commercial development through effective technology transfer. It has also advanced the cause of standardization by providing impartial data on which to base effective industry standards and specifications where there is controversy or no standards at all. Such activities have enabled the adoption of industry standards and specifications by Government and military agencies at great financial savings and increased operating efficiency for us all.

It has also advanced the technical capabilities of small business, small companies, operating within the building industry, companies which could not afford large research expenditures as can our larger corporations. Their ability to sustain major research and development expense has been somewhat alleviated by the development of technology and publication under DOE auspices. DOE's continuing activity, the National Program Plan, has been very successful as measured by participation in conferences and attendance interest in these functions, identification of priority areas most needing new technology development, the initiation of project efforts with subcontractors to address problems and then resolve and public data, and communications, technology transfer effort which accelerates use into current applications.

I would like to focus this subcommittee's particular attention to proposals for increased activity in cooperative research projects conducted jointly with private industry, educational institutions, consumers, et cetera. The great and immediate benefit would be the significant financial leverage provided by pooled resources to include funds, materials, services, research and testing facilities, expert personnel and their experience, abilities, and availability.

Utilizing DOE as a technical and management resource, both knowledgeable and impartial in its judgments, research programs would be proposed and identified for response by organizations with a common interest in participation in cooperative study of a specific research area or issue. Certainly the quality of response would be an indication of project priority and need justification.

Scope, objectives, and task organizations would be developed and monitored by the cooperating organizations under DOE/ORNL management, for example. Only a fraction of the total program effort would be at Federal cost. And the organizations most interested in the implementation of newly developed technology would be directly involved and oriented to its immediate application and utilization in practice. This is a real plus.

The DOE/ORNL Building Materials Research Agenda Panel has developed an extensive list of candidate research projects, and a copy is attached in my prepared statement.

The thrust of Gramm-Rudman-Hollings is to get the most benefit from Federal expenditures within the guidelines of our ability to fund the budget. A $1 million expenditure for the building materials research task in fiscal year 1987 might well return a tenfold expenditure and value provided by the private sector to conduct needed R&D on a cooperative basis. Our investment in existing research and development capability would not be diminished, it would be enhanced, and the rate of technology transfer into application/use would be accelerated.

The importance of energy conservation, Mr. Chairman, demands that we give the private sector a greater opportunity to participate cooperatively and efficiently in the development of needed technology. We all understand the reality of long lead times involved in research, development, and successful commercial adoption. Well targeted research reduces the time to commercialization, return on investment, and is a major factor in achieving technical and commercial success for new technology.

Concluding, Mr. Chairman, the American public currently enjoys the energy efficiency benefits from past research and development effort in building materials research. Their investment has paid off, and paid off handsomely. Continuation of an appropriate and sensibly funded energy conservation program, therefore, is justifiable, is necessary, and must be mandated in the final decision of this subcommittee.

We look to this subcommittee for wisdom and clarity in the use of its legislative power and responsibility, Mr. Chairman, and we look to it to sustain our request for an adequate and effective building materials research task in the fiscal year 1987 budget and appropriation.

And I thank you very much.

[The prepared statement of Mr. Sherman follows:]

PREPARED STATEMENT TO ACCOMPANY TESTIMONY BEFORE
THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE AND TECHNOLOGY

GOOD MORNING   Mr. Chairman, Ladies and Gentlemen

I very much appreciate this opportunity and invitation to speak before you today in support of continuing an effective level of research on energy conservation technologies via the Department of Energy's building thermal insulation program. I have intentionally kept my remarks brief and to the point so that others can also be heard in the limited time available today.

As detailed to some degree in my biography page, I have been involved in private sector thermal insulation research and development for over 30 years, and can well appreciate the positive effects of DOE programs on this industry and the energy conservation methods encouraged and put into everyday use as a result of its advocacy. Although not personally familiar with the details of the President's proposed FY87 budget, it is my understanding that:

(1) energy conservation research and development would be cut by 60% after a nearly 50% reduction since FY 1980.

(2) although the Department of Energy recommended $1MM budget for the Building Materials Research Task, the President's budget does not fund this important program.

This would be a tragic mistake and should not be acceptable to this subcommittee.

I believe there is unanimous agreement that federal budget realities require a very careful and considered review and adjustment of our spending priorities. However, elimination of the Building Material Research Task at a time when its efforts, already proven successful and highly cost-effective, are being directed towards more public sector/private sector cooperative research programs, would be a wasteful stupidity. Current programs directed to develop thermal insulation technologies many times more efficient than today's commodity products would be halted before completion. Applications development to accelerate the adoption of advanced energy conservation into conventional design practice would return to the snail's pace of the 1970's, when cheaper energy costs motivated inefficient methods and energy waste in construction as justifiable.

We should not ignore the very expensive lessons learned since 1973 – that it cost more to catch-up than to maintain an ongoing effort in research and development in energy conservation. We should keep in mind those panic responses, generated by the enormous economic impact of energy cost escalation and compounded by inefficient use technologies and intensive demand. Today's plummeting petroleum prices are the artificial result of manipulated OPEC oil production levels. A nation and economy once more seduced into energy waste and inefficiency lassitude, could just as rapidly be hit by another round of oil price increases after OPEC's objectives have been reached. If this lesson has been learned, we cannot allow productive research and development in building materials technologies to stop. As demonstrated by the proven success of our energy conservation research and development efforts since 1977, our research and development must be a sustained effort to achieve results with cost effectiveness – crash programs are not the way to go. Specialized personnel and facilities, assembled and active, have very low disposition value on termination, and require excessive funding and time to reassemble when the need returns.

I have been directly involved with private sector research and development in foam plastic thermal insulation since 1967. Our company's proprietary product development efforts were helped, not hindered, by federally funded research and development activity on these highly efficient thermal insulations during the early days of the aerospace program. It helped make our work easier and faster and reduced our technology needs to those areas yet to be investigated. It helped to put our products in-place to be available for enhanced use/broader commercialization at the initiation of the 1970's energy crisis. Current Building Materials Task efforts, in much the same way, can continue current work on advanced insulation materials and systems so as to have them in place and available when that 1990 oil crisis hits us all.

Some current DOE/ORNL project activities that can add significantly to the technology base available for future energy conservation applications include:

(1) Development of advanced thermal insulation for appliances
D. McElroy & Assoc./ORNL

(2) Gas diffusion and thermal conductivity of foam insulation versus age
L. Glicksman & Assoc./MIT

(3) A variety of testing methods under development to measure thermal performance of systems in-place.

The Department of Energy has defined a roll for federal research and development in those areas where the incentives for and availability of private investment are severely limited or non-existent, providing options for private investment and commercial development through effective technology transfer. It has also advanced the cause of standardization by providing impartial data on which to base effective industry standards and specifications where there is controversy or no standards at all. Such activities have enabled the adoption of industry standards and specifications by government and military agencies at great financial saving and increased operating efficiency for all concerned. It has also advanced the technical capabilities of small companies operating within the building industry, companies which could not afford large research expenditures as can larger corporations. Their inability to sustain major research and development expense until commercialization has been somewhat alleviated by the development of technology and publication under DOE auspices, e.g., national conferences and publications communicating newly developed energy conservation technologies. It's continuing activity, The National Program Plan, has been successful as measured by (1) participation in conferences and attendance interest in these functions, (2) identification of priority areas most needing new technology development, (3) initiation of project efforts with subcontractors to address problems, then resolve and publish data, (4) communications, technology transfer effort which accelerates use into current applications.

I would like to focus this subcommittee's attention to proposals for increased activity in cooperative research projects conducted jointly with private industry, educational institutions, consumers, etc. Utilizing the Department of Energy as a technical and management resource, both knowledgeable and impartial in its judgements, research programs would be proposed and identified for response by organizations with a common interest in participation in cooperative study of a specific research area or issue. The quality of response would be an indication of project priority and need justification.

A great and immediate benefit would be the significant financial leverage provided by pooled resources to include funds, materials, services, research and testing facilities, expert personnel and their experience, abilities, and availability, etc.

Scope, objectives and task organization would be developed and monitored by the cooperating organizations under DOE/ORNL management. Only a fraction of the total program effort would be at federal cost, and the organizations most interested in the implementation of newly developed technology would be involved and oriented to its immediate application and utilization in practice.

The DOE/ORNL Building Materials Research Agenda Panel has developed an extensive list of candidate research projects, judging 24 as most significant after recognizing accomplishments and advances made over the preceeding years towards achieving National Program Plan objectives.
A copy is attached to my prepared statement as information.

The thrust of Gramm-Rudman-Hollings is to get the most benefit from federal expenditures within the guidelines of our ability to fund the budget. A $1 million dollar expenditure for the Building Materials Research Task in FY87 might well return a tenfold expenditure/value provided by the private sector to conduct needed research and development on a cooperative basis. Our investment in existing research and development capability would not be diminished and the rate of technology transfer into application/use would be accelerated.

The importance of energy conservation and use efficiency demands that we give the private sector a greater opportunity to participate cooperatively and efficiently in the development of needed technology. We all understand the reality of long lead times involved in research, development and successful commercial adoption of new technology. Well-targeted research and development reduces the time to commercialization and return-on-investment, and is a major factor in achieving technical and commercial success for new technology.

The American public currently enjoys the energy efficiency benefits from past research and development effort in building materials research. Their investment has paid off handsomely. Continuation of an appropriate and sensibly funded energy conservation program, therefore, is justifiable and necessary, and must be mandated in the final decision of this subcommittee.

We look to this subcommittee for wisdom and clarity in the use of its legislative power and responsibility, and that it sustain our request for an adequate and effective Building Materials Research Task in the Department of Energy's FY87 budget and appropriation.

Thank you.

Morton Sherman - Written Statement to accompany oral testimony before
The Subcommittee on Energy Development and Applications
U. S. House of Representatives
Committee on Science and Technology
Thursday morning, March 6, 1986

Index of Attachments

1. Personal biography - Morton Sherman

2. Excerpts from ORNL/Sub/84-97333/1, "Building Materials Research Agenda" by E. Bales, New Jersey Institute of Technology.

    a. Abstract

    b. Project titles (24), pages 30 and 31

    c. Discussion of Cooperative Project Mode, pages 95 thru 99

3. Magazine article - "A Lawyer's View - Cooperative Research Comes of Age" by Gerald S. Green, RESEARCH AND DEVELOPMENT, January 1985, page 29.

4. Magazine article - "Science Policy - Research Data Should Be Shared" by Ted Agres, RESEARCH AND DEVELOPMENT, August 1985, page 47.

BIOGRAPHY

MORTON SHERMAN

Morton Sherman is currently a Project Manager in the Commercial Development Group of the Jim Walter Corporation, Tampa, FL. Prior to undertaking this responsibility for the parent corporation, Mr. Sherman served as Senior Research Associate in the Cellular Plastics Department of Jim Walter Research Corp. (JWRC), its R&D division headquartered in St. Petersburg, FL. In that capacity, Mr. Sherman supervised research technical service and development effort on new and improved thermal insulation systems (five U.S. patents), with continuous and direct involvement in cellular plastics thermal insulation product research and development at JWRC since 1967. Prior to joining Celotex Research, a forerunner of JWRC, in 1960 to develop acoustical and thermal insulation products made with bonded mineral fibers, he was employed by the Zonolite Company Research Laboratory in Evanston, IL to conduct new product development research in vermiculite insulating concretes and plasters for their acoustic, thermal insulation and fire resistive benefits.

Mr. Sherman has a chemical engineering degree from the Illinois Institute of Technology in Chicago; he has served on several technical committees of the Polyurethane Division of the Society for the Plastic Industry, on ASTM C9 (Concrete), C33 (Acoustics) and D20 (Plastics), is currently on the Executive Subcommittee of ASTM C16 (Thermal Insulation) and immediate past chairman of its Subcommittee C16.22, "Organic and Non-Homogenous Inorganic Thermal Insulations". He is Chairman of the Research Coordinating Committee on Building Thermal Envelope Materials, serves on the Board of Directors of the Building Thermal Envelope Coordinating Council, and has also served on the Critique Committee, National Plan (1979) for Research on Building Thermal Envelope Systems and Insulating Materials, and the ECUT Thermal Insulation Materials Project Advisory Panel.

Mr. Sherman has authored and published many technical papers covering such diverse topics as insulated metal building roof systems, the moisture-related performance and fire response characteristics of various insulated wall systems, and thermal measurement, materials sampling and physical testing technology.

To [illegible] REPRODUCTI
IN FEBRUARY, 1986

ORNL/Sub/34-97333/1

BUILDING MATERIALS RESEARCH AGENDA

E. Bales
New Jersey Institute of Technology

ABSTRACT

An ad hoc panel of individuals was organized to propose a research agenda, scope and objectives that the DOE/ORNL Building Materials Research Program should pursue. The panel recognized accomplishments and advances made over the past five years in selecting agenda projects. The panel composed an extensive list of candidate research projects and selected twenty-four as most significant. Each of the twenty-four projects was characterized by two paper descriptions which detailed objectives, scope, problem significance, technical approach, and research products. The panel recommended that DOE/ORNL consider these projects for funding over the next three to five years.

The panel also recommended that the Building Materials Research Program adopt an Advanced Program Scope that supports applied research. The research results of the recommended projects will provide information on materials used in combination to satisfy multiple functions within a building.

In addition, the panel suggests that a Cooperative Project Mode alternative be considered. A cooperative project involves a group of organizations that have common interest in a research issue. The DOE/ORNL program managers would take the lead in establishing ad hoc groups with an interest in pursuing research of mutual interest. The group would pool its resources to accomplish a common objective and in directing the research. The research issues that would benefit the most are those that do not seem to be within the purview of any particular element of the building community but of concern to all. Selection of a scope and tasks will be by consensus; members of the group will have common goals and objectives.

Research sponsored by the Office of Buildings and Community Systems, Building Systems Division, U.S. Department of Energy, under contract DE-AC05-84OR21400 with the Martin Marietta Energy Systems, Inc.

PROJECT DESCRIPTIONS

I. Materials Science

IA1	Thermophysical properties of concrete masonry units in relation to composition
IA2	Thermophysical properties of wood and wood products
IA3	Thermophysical properties of laminated composite building materials
IA13	Development of high strength bonding and sealing materials
IB1	Building insulation system thermal anomalies
IB2	Analysis of the combined modes of heat and moisture transport
IB4	Characterization of dynamic thermal performance of building components and assemblies
IB6	Thermal performance of hollow masonry units in wall construction above and below grade
IC1	Test methods and measurements for outgassing of materials
IC2	The coefficient of thermal expansion of laminated composite building materials
IC6	Develop test procedures for determining thermal properties of materials affected by moisture
IC7	Development of methods for in-situ measurement of moisture in building materials
IC9	Development of small-area screen heat source capability for measuring thermal transmission characteristics of small-area materials specimens
IC10	Develop standard test procedures to measure dynamic thermal properties of materials
ID5	Determine performance of materials and composities under cyclic wetting and drying conditions

II. Materials Design

IIA1	Performance of underground insulating materials
IIA3	Development of low conductivity materials for use as ties and lateral reinforcement in concrete, masonry, wood and composities
IIB1	Effects of moisture absorption and release on thermal properties and durability
IIB3	Design of construction joints of different materials and adjacent joints using the same material
IIB4	Development of guidelines for the improved application of building materials in energy efficient construction
IIB5	Establish a large-scale test facility to study the long-term performance of wall, roofs and floor materials in combination under exposure to dynamic thermal, moisture and mechanical stress conditions
IIB8	Measure the thermal performance of a number of typical generic wall constructions to establish current practice
IIB10	Heat and mass transfer measurements of insulated roof/ceiling constructions using a calibrated hot-box
IIC2	Transfer NASA technology for improved multipurpose vapor and air barriers

V. Cooperative Project Mode

A desirable characteristic for federally supported research is to have the broadest private sector and professional support possible. Funding is usually justified on the basis of meeting needs of the building sector. In addition it is a policy that federal funds be awarded upon competitive bidding unless there is a unique potential contractor. On a competitive basis, a single best proposal must be selected from those submitted. Frequently a non-winning proposal will have a unique, desirable feature that cannot be pursued because it is not in the winning proposal. An alternate to the usual funding procedures is a Cooperative Project Mode.

Description

A cooperative project is one in which ORNL/DOE would seek out those interested in the research results. A public call for cooperators could be made. Applications would then be evaluated for technical capabilities and experience. ORNL then issues invitations to form a group to define and undertaken the necessary research work for a particular project. At the initial meeting of the group, a general description of the project, similar to the project descriptions, would be offered as the basis for discussion. The group decides whether the proposed project is relevant and then writes a scope and lays out a research plan including a division of resource responsibility. Resources include dollars, in-kind professional services, and equipment. Partners need not contribute equally or provide the same or all resources. Some will have strength in only one aspect, e.g. a unique piece of equipment or a uniquely knowledgeable individual.

General Procedure

Careful planning with consensus of the group will be required. A manager, not a researcher, from ORNL should take the lead in the discussions and the eventual project to ensure impartiality and expedite progress. It should be clear from the beginning that all research results are to be published, negative as well as positive results. The form and style of presentation will be by consensus of the group.

The initial step is an identification of a project suitable to a group of cooperators. It should not be product development as that is a private sector responsibility. With ORNL leadership the group will determine what is to be done, how the work will be supported, and who will undertake the separate phases of the project.

It is then an ORNL responsibility to act as the focal point for the arrangement of funding, internally and externally. Usually there will be contributions from several sources which will need to be organized, assimilated, and coordinated.

It will also be ORNL responsibility to keep all cooperators fully informed. This might best be done with quarterly progress briefings including scheduling and resource updates. Any change in project direction, which is a group responsibility, could be reviewed and approved at the briefings. The group will provide strong direction and cause the researchers to defend work in progress rather than at the conclusion when it may be too late to recognize and take advantage of new suggestions.

An alternative is to use an outside organization to manage the project with ORNL only as a research partner. The outside organization could be an Association to which most of the partners belong, for example, one of the Research Coordinating Committees of the Building Thermal Envelope Coordinating Council (BTECC). In any case a strong individual manager is needed who can deal with the fiscal arrangements and the technology involved and who can manage a group on a consensus basis.

V. Cooperative Project Mode

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V. Cooperative Project Mode

An Example

An example of a cooperative project is one initiated by Jim Walter Research which was led by the Forest Products Laboratory.

Jim Walter Research Corporation was concerned about the comparative moisture performance of plastic foam sheathing products under actual service conditions. There are several types, and manufacturers were not consistent in the descriptions of the flow of moisture through wall sections. The Forest Products Laboratory (FPL) was asked to consider a field test project comparing the generic plastic products with fiberboard sheathing. During the initial dialogue, there was an expression of interest to include others in documentating design guidelines for moisture control through walls. Eventually, Dow Chemical, the American Hardboard Association, the U.S. Department of Housing and Urban Development (HUD), and the National Forest Products Association (NFPA) joined Jim Walter Research and FPL in this cooperative research effort.

Tests buildings were built in Madison, Wisconsin and Gulfport, Misissippi by the FPL. Research progress was monitored periodically by the cooperator group. The FPL researcher also managed the cooperative aspect of the project. When interviewed by telephone for this effort, in retrospect the FPL researcher considered the technical support and direction from the group valuable but thought the management of the group interfered with his research. He suggested that an alternative would have been for the NFPA Technical Committee to act as the coordination group. FPL could have provided project briefings.

Benefits

There is an obvious and significant amplification of effort and resources. Knowledgeable people and valuable resources are quickly assembled and focused on a particular issue. Many of the people and resources would not be normally available to a DOE/ORNL project. Specific benefits are:

- continuous and immediate technical feedback to the research project while it is in progress.
- sharing of the funding responsibility
- combined concerns on project issues
- combined talent and experience on research
- all cooperators get immediate benefit of research as it progresses
- drawing together diverse organizations usually separated by proprietary interests
- stimulate the release of proprietory data by the cooperators to attain project objectives
- prompt dissemination of the results
- provides an open technical interface and a forum for exchanges between suppliers and users of building materials
- project results are more quickly communicated, understood, accepted and put into use to the benefit of designers
- in some projects, cooperators from several different building product types will work together to solve common problems
- accomplish research that relatively small organizations cannot accomplish alone

Drawbacks

A project that must satisfy several cooperators will inherently be more difficult to manage. Proposals for changes in scope and/or direction are more likely. Specific drawbacks include:

- requires careful planning and coordination of the cooperators by the project manager
- must satisfy many different interests
- project has a high risk for over budget spending because of project

V. Cooperative Project Mode

direction changes requested by the coordinators
- technical results that may be considered negative by some cooperator interests may tend to be suppressed

Suggestions

Those projects concerned with the issues that are not proprietary products related would fit into a cooperative mode. That includes nearly all those supported by ORNL/DOE. Examples of generic building material projects that might be developed as cooperative projects are: concrete masonry units (IA1), log building (IA2), and underground materials (IIA1).

Particular performance issues of concern to users, sometimes termed marginal or negative properties, need the focus of private sector expertise. The research generally will not be done, or at least published, because the results are usually not expected to provide competitive advantages. These issues include fire safety, corrosion, aging, shrinkage, settling, and toxic emissions. Projects to develop data bases are particularly well suited for a cooperative venture.

A LAWYER'S VIEW

GEREN LOOKS AT
LAWS AS THEY MAY
AFFECT YOU IN R&D

Cooperative research comes of age

THE NATIONAL Cooperative Research Act of 1984 (PL 98-462) was signed into law in the U.S. by President Reagan on October 14.

This law helps to open the door to cooperative research between competitors through the establishment of joint ventures for research and development purposes and/or through use of trade associations as the research and development arms for their respective industries.

Prior to enactment of this law, there existed the "paralyzing fear" that joint research and development activities between competitors would be an antitrust violation, subjecting the competitors to treble damages.

In an obvious attempt to spur innovation, research, and development within the United States and thereby meet foreign competition, several bills were introduced in Congress for the purpose of eliminating or minimizing the antitrust restrictions on joint R&D projects.

The National Cooperative Research Act is the result of several of those bills. It is important to note that there are, already in existence, some cooperative research ventures, one having been established in Austin, TX, by major computer firms for microelectronic research.

Now, under this law, several competing companies within an industry, trade association, etc., can legally band together to do research which separately they could not afford, or which would not be profitable.

The principal effect of this law is to minimize the impact of antitrust laws on such efforts. That was done by reducing the level of damages from treble damages to actual damages suffered by a plaintiff.

Additionally, a joint project is to be evaluated under a *rule of reason* approach to the antitrust laws rather than *per se* evaluation. In other words, the rule of reason is used to determine whether or not, when all factors are considered, the joint research project is anticompetitive.

Finally, in order not to completely prevent an injured party from challenging the venture, the defendants (*i.e.*, joint venturers) can only recover attorneys' fees from the plaintiff if the claim was frivolous and without foundation. Thus the plaintiff still has the option to bring well-founded litigation without the fear of attorneys' fees being awarded against it.

In order to obtain the benefit of rule of reason and reduction of damages, the act provides certain definitions of what is research, a notification requirement to the attorney general, and a publication requirement.

In terms of definitions, joint research and development ventures generally relate to what one would normally consider to be pure research, development, and testing of engineering principles, application of the technology and demonstration of its usefulness, collection of research information, and obtaining of patents and granting of licenses as to the results of the technology.

The definition of joint research and development does not include commercialization of the technology. Presumably, the developed technology is to be licensed back to the joint venturers and/or others for its commercialization.

Significantly, the act also includes exclusions from joint research and development. Those exclusions generally relate to the traditional areas of antitrust violation such as competitors sharing commercial data on sales, costs, and distribution; restricting marketing efforts, sales, and licensing; etc.

In other words, the bill defines research and development and what can be done with it and the licensing of the related technology, but attempts to avoid the problems of sharing of commercial information which could result in a traditional antitrust violation, such as price-fixing.

In order to gain the benefits of the rule of reason and limitation on damages, disclosure of the joint R&D venture to the attorney general is essential. The written notification provision requires the identities of the parties to the venture and a statement of the nature and objectives of the venture.

Thereafter, the notice is published in the Federal Register with respect to the venture, identifying the parties and—in general terms—the areas of planned activities. It appears that all other information such as proprietary information, technological information, etc., which may be obtained by the attorney general in connection with the joint research project is exempt from disclosure.

Assuming that the venture meets the appropriate definitions, notice is filed, and publication is made, the venture can proceed.

Any plaintiff who feels that there is antitrust violation arising from the joint research and development activities still is entitled to litigate under the antitrust laws. However, in any such litigation the venture shall not be deemed illegal *per se* and will be judged on the basis of its reasonableness.

The act specifically provides that all relevant facts will be taken into consideration in evaluating reasonableness, including those affecting competition and relevant research and development markets. If the plaintiff is successful, it shall recover actual damages, not treble damages.

With respect to attorneys' fees, the court shall award the cost of the suit including attorneys' fees to the "substantially prevailing claimant." In other words, if the plaintiff is successful, it will recover its attorneys' fees.

On the other hand if the defendant is successful in defeating the claim, it can only obtain its attorneys' fees if it is shown that the plaintiff brought its claim without foundation, in bad faith, etc.

It is the object of this article to provide only a brief overview of this legislation. In order to gain a full understanding of the intent of the legislation, its scope and its limitations, any specific project must be considered against the act and in light of the legislative history in Congress.

It is clear that this legislation is a major step forward in removing barriers to cooperative research within an industry. While on the surface this appears to be significant principally to high technology areas of research, such as microelectronics, it is very possible that the more mundane "low tech" industries may benefit the most.

For example, the metals industry may find this bill very useful in terms of materials and process research for the steel and foundry industries, or the fastener industry for materials and design research.

It is to be expected that cooperative research will begin at a slow and cautious pace to see how the law and such cooperation can develop. But it is also predicted that the pace of such research will accelerate rapidly thereafter.

Gerald S. Geren

Gerald S. Geren specializes in intellectual property law with the Chicago firm of Hill, Van Santen, Steadman & Simpson.

This column is presented for educational and informational purposes and is not intended to constitute legal advice. Any reader who encounters a legal problem in this field is encouraged to obtain the advice of an attorney

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SCIENCE POLICY

'Research data should be shared'

SCIENTISTS ENGAGED in original, independent research should be required to share their experimental data with others, allowing colleagues—and competitors—the opportunity to verify or refute their findings.

This is the conclusion of a recent study conducted by the National Academy of Sciences' National Research Council (NRC). The council's Committee on National Statistics examined the issues surrounding the sharing of research data and determined that the advantages to doing so outweighed the disadvantages.

Committee Chairman Stephen Fienberg of Carnegie-Melon Univ. pointed out that data sharing has numerous advantages: it reinforces open, scientific inquiry; it permits verification, refutation, or refinement of original research results; it stimulates improvements in measurement and data-collection methods; it allows more-efficient use of resources spent on data collection; and it discourages the "uncommon, but nevertheless serious" problem of fraudulent research.

"Disputes among scientists are common," the report states. "Without the availability of data, the diversity of analysis and conclusions is inhibited and scientific understanding and progress are impeded."

The committee noted that there are many factors working against an open exchange of research data, not the least of which are patent rights and commercial potential. In the case of biotechnology, for example, a new processing technique could have significant market value in a rapidly-growing field.

Other problem areas include privacy of survey respondents as well as the cost involved in duplicating the data for interested parties.

Perhaps the greatest impediment, the NRC panel noted, is the fear that an independent reanalysis might reveal flaws in the original research, which may substantially alter its conclusions or invalidate it completely. The panel noted that these fears may, in fact, be justified. Additionally, "sloppy" reanalysis, even if successfully defended against, will necessitate the spending of extra time and effort that could be spent on additional original research.

To balance out these conflicting interests, the panel recommends that data sharing be increased, but that agencies that fund research (such as agencies of the Federal government), research journals, professional societies, and individual scientists work to find a way that balances the conflicting rights and interests of all of the parties involved.

The committee came up with four recommendations:

☐ Researchers should share their original data whenever practicable and at the earliest opportunity, ideally at the time of initial publication of any major results. These data files should be well documented and contain information on how the data were obtained. The files should be available either from the original researchers or from an appropriate data-archiving service.

☐ Those researchers who request the original data should pay all costs involved in obtaining the data, should acknowledge the original researchers in any reanalysis published, and should keep their requests for assistance from initial investigators to a minimum.

☐ Government agencies and other funding sources should require applicants to guarantee that data will be shared or to "justify explicitly, in their proposals, why sharing would be inappropriate."

☐ Scientific and technical journals should require researchers to provide access to their data during the peer review process. Some journals already follow this practice, but it should be conducted by all.

"We need to instill in the scientific community the ethical notion that data sharing is a scientific responsibility," Fienberg states. "You simply cannot be a responsible public scientist without letting people go all the way back to understand the basics."—*Ted Agres* ☐

Mr. FUQUA. Thank you. Thank you very much, Mr. Sherman. Dr. Patten, what are some of the—in your opinion—some of the promising energy system technologies that probably we're not giving enough emphasis to right now?

Mr. PATTEN. That's an interesting question. There are some systems that are under development, some at Cummins Engine Co., that involve diesel and gas turbine combination systems, and involve new forms of combustion. But typically, I think private industry has tended to hold these technologies close the vest, as it were, rather than proposing them for Government funding or for research and development in Government laboratories.

I think that that is because once we have engaged in an R&D effort with a laboratory like Oak Ridge or with a DOE funded program from DOE headquarters, the nature of the work, at least, and very often the details of the results become publicly known. And you've given away a major strategic advantage, particularly if you're concerned with competing worldwide, as Cummins Engine Co. is.

So I'm giving you a long and rambling answer to a very simple question. I think there are several systems like that, like the ones that I have mentioned, that are available, that are being researched, that are not being attended to or are not being attended to in the most highly leveraged technological areas, but there are good reasons for that. I don't know how to lick that problem. That is a traditional problem, I think, in fostering close relationships between private industry and Government agencies.

Mr. FUQUA. Why should we give that emphasis?

Mr. PATTEN. Why should we give that emphasis? Why should we take a run at those kinds of particular problems? In my own personal view, and I'm sure this should not be construed as——

Mr. FUQUA. I'm speaking kind of as a devil's advocate. I'm speaking as a devil's advocate.

Mr. PATTEN. Yes, I understand. Traditionally I think the view is that you should not. That work that's funded by the Federal Government should be available to everyone, that it should—since it's done under public funds—should be available to literally anyone who needs the information.

However, if you follow that philosophy, then the most significant work that private industry finds most valuable cannot be done in a complete open forum because it gives away a potential for international competitiveness. That's particularly true when we find ourselves in a situation where the tax structure and the regulatory structure in the United States places a particularly short time horizon on our R&D investments, and a horizon that really isn't a reality for, for instance, our Japanese competitors.

So if we give away our most important long-term strategic thinking and our early scientific results to people that can afford a longer R&D horizon than we can, we've placed ourselves at a serious technical disadvantage. That is a very, very crucial problem, I think, to be addressed in the United States. It goes right to the heart of our technological disadvantage.

I believe that in particular, some of these areas that I've mentioned—combustion systems, tribology, materials—are seeing some very rapid technological advance. I hesitate to say a breakthrough because almost everything of real significance occurs as a whole series of very substantial and well directed steps. But we are clearly losing technological ground to overseas competitors.

We are seeing, for instance, in the ceramics business something like a two orders of magnitude difference in the number of people working on long-term ceramics R&D in Japan relative to this country.

Mr. **Fuqua**. Well, is that technology transfer, are you satisfied with the way it's handled now?

Mr. **Patten**. I think we're learning. I think within the constraints of our economic system, and so forth, that we're really improving at that.

Mr. **Fuqua**. We. You mean your company or DOE or jointly?

Mr. **Patten**. We as a nation are learning. I think ourselves, Cummins——

Mr. **Fuqua**. Well, let us speak to the DOE programs, though.

Mr. **Patten**. Yes. I think in some areas in DOE it's becoming much more effective. The thrust in the last few years to give special consideration to programs that are cost shared is definitely a step in the right direction. That strategy now lets a company like Cummins propose work that we need to hold some proprietary interest in to DOE, to cost share that work, and to own the inventions that come from the work. But all of the rest of the strategic thinking and the intellectual property that is not patentable, that would normally be held close to our vest, still gets talked about in reviews and conferences and so forth, and gets disseminated to people pretty broadly.

And I have to tell you, when you attend as many technical sessions worldwide as I do, it's pretty clear that our foreign friends are taking very, very astute advantage of the information that we disseminate.

Mr. **Fuqua**. Well, what we are really interested in is in a situation involving your company, say ceramics. Now, I don't think it's the Government's job to tell you how to build an engine. You know more about that than the Government does. But I think it's important to make available to you all the information that we have about ceramics.

Mr. **Patten**. Yes.

Mr. **Fuqua**. And then you take it——

Mr. **Patten**. Yes.

Mr. **Fuqua** [continuing]. And apply it the best way you know how to for your company.

Mr. **Patten**. Yes. And I think that's well done.

Mr. **Fuqua**. And you're satisfied with that part of it.

Mr. **Patten**. I think that we are growing in that area. The ceramics program is one that's particularly strong in that way. It's managed particularly well, I believe. I think if you look at something like this nickel aluminide program, you can see a nucleus of new thinking that I think will be particularly effective in the technology transfer area.

We have been the first to sign an actual license agreement to begin putting money on the table for cooperating on the nickel aluminide technology. Currently, as of yesterday, in conversations with Martin Marietta people at Oak Ridge, there are over 40 other companies actively investing in the nickel aluminide technology in trying to decide whether or not it's in their best interest to take a license, if that's the best way to develop the technology and to move forward.

One of my acquaintances that is responsible for the Government funded materials programs in Germany is starting a very aggressive cooperative program in Germany to pursue the nickel aluminide technology. And several of our friends in Japan are doing likewise.

So I think the system that Oak Ridge has fostered for working together between industry and Government laboratories is without precedent worldwide. It is a better system than any of our competition—international competition—have. But is it the first example of that kind of an activity?

So, as I say, there are a lot of people with their hearts in the right place, and we're learning, but technology transfer is a major issue for us.

Mr. **Fuqua**. How about you, Mr. Sherman, in your experience with DOE?

Mr. **Sherman**. Regarding technology transfer?

Mr. **Fuqua**. Yes.

Mr. **Sherman**. Technology transfer, in my experience, with the building materials research task has been superb. Superb because of the concerted and well-directed effort to disseminate knowledge through conferences and symposiums, bringing technical papers out of the private sector and into the public sector for dissemination and discussion, dialog and refinement.

The technical process benefits from this sort of dialog. Questions can be asked, hard questions, which can be considered in both public and private laboratories and returned with answers. That has been one of the shining jewels of the materials task effort. The creation of the building thermal envelope coordinating council, of which I am one subcommittee chairman, has been effective in focusing attention on research needs. Not conducting the research, but identifying the priorities; where the needs are and which ones are worthy of address.

And these research topic agendas have become the basis for discussion concerning cooperative projects. Cooperative projects participated in by many groups, both organizations, producers, and so forth, but also users and universities and others interested and able to provide a component of the program other than funds.

In our particular case, in a round robin study of a particular sophisticated test method, we had in place a capability, a testing capability, that would have a replacement cost of $250,000. The Government didn't have to build one to get the use of our capability as a cooperative venture. And this has been a valued benefit to all concerned, and should be encouraged.

Mr. **Fuqua**. Have you found, since the change in the last year or so in oil prices, that the awareness level of consumers in energy efficient homes, has it——

Mr. **Sherman**. It's quite interesting, Mr. Chairman. It's been our experience that the home building community, the industry, has recognized the saleability of energy effectiveness in construction better than State energy boards, code driven, and mortgage-driven efforts to drive it.

The result has been that the builders, generally speaking, and not everywhere, but generally speaking, tend to feature energy effectiveness so that the energy use costs are less than a mortgage cost. This will be a challenge as mortgage costs come down.

I think, however, that the consumer has been made aware, and the DOE effort has been a major factor, in causing and maintaining that awareness. The programs that we have put in place since 1977 have been effective. They are cost effective, and to eliminate them now would be to deteriorate the future circumstance. I think that the homebuilder will continue to feature energy saving, and the near future will be good, independent of fiscal year 1987.

However, I think that it could deteriorate to where the new buyer coming in a year or two from now might look at gold-plated faucet handles with a different view than insulation.

Mr. FUQUA. Also with the reduction in crude oil prices, it really hasn't impacted in a general sense the cost of energy to heat and cool their homes.

Mr. SHERMAN. I'm unfamiliar with the——

Mr. FUQUA. Well, most of the electric energy, and so forth, has remained relatively stable.

Mr. SHERMAN. That's correct.

Mr. FUQUA. That has not been dramatically impacted because of the crude oil prices.

Mr. SHERMAN. That's correct. In Florida, for example, particularly——

Mr. FUQUA. It may affect his automobile driving habits, but it hasn't impacted really in the home. And that's a considerable item in a budget now.

Mr. SHERMAN. Yes, sir.

Mr. FUQUA. I want to thank you gentlemen very much for being here, and—did you have——

Mr. PATTEN. Yes, Mr. Chairman. If you would like, I'd be glad to prepare a list of technology areas that might be promising to pursue and submit that for the record at a later time.

Mr. FUQUA. Yes. If you would do that, we would appreciate that.

Mr. PATTEN. All right.

[Responses to additional questions follow:]

ED&A)

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PLEASE REPLY TO:
Commercial Development Group
10301 Ninth Street North
St. Petersburg, Florida 33702
(813) 576-4171

April 15, 1986

Congressman Don Fuqua
Chairman, House Committee on Science & Technology
Suite 2321, Rayburn House Office Building
Washington, DC 20515

Re: SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
March 6, 1986 Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for Conservation

Dear Congressman Fuqua:

Thank you very much for your rather complimentary letter of March 10, 1986. I regret that a heavy travel schedule interfered with my prompt response to the questions posed in your letter, but I trust this letter will still serve your needs as a supplement to the record of the hearing.

Question 1

There are two programs dealing with building materials R&D, one in the Solar program, the other in the Conservation program. Do you utilize data from both these programs? If you do, would it be more helpful if they were combined into a single group? What advantages do you see in their remaining separate? What advantages do you see in their being combined, both from a cost standpoint and for testing and reporting?

Response

While our company has utilized technical information from both the Solar program and the Conservation program, we believe that the broader scope and applicability of Conservation program research and technology development activities has had the greatest impact to-date. Yes, it has been somewhat inconvenient to monitor these as separate programs, and we believe that their combination under one program management could offer some supervisory cost reduction and technology transfer advantages, such as unified conference and publication activities. Subcontracted project effort should remain diversified, and increasingly oriented to the cooperative mode endorsed in our original presentation.

Question 2

How have results from the DOE buildings R&D program benefited you, as the builder, and your customer, as the homeowner?

Jim Walter corporation
Commercial Development Group

Response

Results from the DOE buildings R&D program have benefited our activities in a wide variety of circumstances. As a homebuilder, we find a heightened level of energy conservation awareness and understanding in the options selected by our new-home customers. R-value concepts are better understood and appreciated, and intelligent, energy conservation-effective decisions are more readily arrived at. We believe that these educational/technology transfer accomplishments have been possible because of the on-going, time-continuous nature of the Conservation program. We believe that its discontinuance or underfinancing to a point of ineffectiveness, would be an unintentioned signal to the home building/home buying community, that energy concerns no longer exist.

Question 3

Cooperative Venture R&D Pools have been proposed by the DOE Fossil Energy and Conservation and Renewable Energy programs. In fact, the Fossil Energy FY 1987 budget request includes $12.5 million for this initiative. Might Jim Walter be interested in participating as a partner in these pools?

Response

We are not aware of the details and particulars of the DOE Fossil Energy and Conservation and Renewable Energy programs you mention. However, our corporate involvement in fossil energy resources is well known (Jim Walter Resources/Coal, Iron and Chemicals Division operates coal mines and methane gas production facilities near Birmingham, AL), and we would certainly be interested in learning more about the cooperative venture R&D pools proposed in the FY 1987 budget request. If this is meant to be a pilot program budget, or a program of very limited scope and very few individual projects, the $12.5 million requested should be adequate. We would appreciate additional information on this program proposal at your earliest opportunity.

Respectfully Submitted,

Morton Sherman

Morton Sherman
Project Engineer
Commercial Development

cc: J. E. Ross

Cummins Engine Company, Inc.
Box 3005
Columbus, Indiana
47202-3005

May 6, 1986

Representative Don Fuqua
Chairman, Committee on Science & Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Bldg.
Washington, D.C. 20515

Dear Mr. Fuqua:

Thank you for your interests in my opinion concerning Energy Development R&D funded by DOE.

I am (obviously) tardy in answering the four "followup questions" you sent to me on March 6. Three of these questions, your numbers 1, 2 and 4, are relatively easy to deal with as follows:

1. My past exposure to DOE has been both with the Office of Energy Research (OER) and with the Conservation program. I cannot, however, judge how well technology flows from OER to Conservation. I know some of the individuals involved, am aware that they try to accomplish this flow, and have no reason to doubt that they are successful. I just do not have enough data to personally judge effectiveness.

2. In the future, if I see need for possible basic research, applied research, or development, I will follow the same process in getting this information to DOE as I have followed in the past (and am currently following). That is, I will first gain a consensus inside Cummins on the nature of the technical need and gain agreement that involving DOE is consistent with Cummins business objectives. I will then contact DOE staff directly and personally brief them on details of

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our thinking. During this briefing process I will clearly indicate information that is regarded as confidential to Cummins, but I will provide this information freely in an effort to provide understanding of the technical problem and to potential impact on both U.S. business and U.S. energy conservation. I will also, if requested by DOE, help develop strategy for attaching to suggested technical work.

4. Cummins might be interested in participation in a Cooperative Venture R&D Pool, but the probability is not high. In general, most of our external R&D expenditures are carefully focused on specific projects or technology developments that we expect to yield a unique competitive advantage to Cummins. I would guess that most R&D Pools would not line up closely with our specific technical objectives and at the same time provide us with a unique competitive advantage. We are, however, very open to suggestions for new ways to work and new opportunities to build technical strength.

The difficult question, your number 3, has prompted me to delay writing this letter. It is a very penetrating and demanding question that I am still unable to deal with adequately. I would like to give you a full, open, and helpful answer, and at the same time I want to give you the courtesy of answering promptly. In an effort to accomplish both of these ends, I will provide you with a partial answer now, will continue to gain consensus within Cummins on a more detailed answer, and will provide you with a more detailed written response soon. In addition, after you have reviewed this second written response, I would like for you to consider allowing me to discuss our thoughts with you personally.

Your question number 3 had seven parts as follows:

A. Are there promising energy system technologies to which we (DOE) are not giving enough emphasis?

B. If so, what are they and why should we give them more attention?

C. Are there some programs or technologies to which we should be giving less attention?

D. If so, what are they and why?

The answer to A is clearly yes; there are promising energy system technologies that are not being (and should be) pursued by DOE. The difficulty in correcting this situation begins with B. Inside of Cummins we have recently identified at least two major new technical approaches that are likely to yield large improvements in transportation system performance (several hundred percent improvement in vehicle MPG and extended fuel tolerance have been demonstrated, and can be further expanded, by very conservative engineering people). We are, however, reluctant to share our thinking outside of Cummins because of the potential impact on our business. As a result, we have not moved quickly to discuss these thoughts, or our early results, with DOE or with you. However, we are coming to grips with this issue, and I fully expect to be able to discuss this work with DOE and with you in a way that will allow joint Cummins-DOE development of the technology, without jeopardizing Cummins' business position. The process has already begun, with consensus building inside of Cummins. Also, on April 14 and 15 we met with DOE representatives at our Columbus, IN Technical Center to begin exploring the "art of the possible" with respect to working closely together in such a sensitive area. When I write to you next, I hope to be able to report specific positive conclusions and at least one suggested area to pursue, including estimated payoff and details of the technical approach. (DOE could help to reduce industry passiveness by adopting and stressing a more liberal policy with respect to patents and technical information. In particular, distribution of key technical information to foreign competitors is a sore point with industry today.)

The answer to part C is, again, relatively easy to deal with. I feel quite strongly, as does the general technical community, that results to date clearly rule the Stirling engine out of consideration for vehicle application (transportation systems) for the forseeable future. There may be sensible applications for these systems in providing stationary power in remote or primitive locations, but they just will not be competitive with other engine systems in vehicles. I also clearly believe that automotive gas turbines cannot compete with state-of-the-art diesels, or with other developing internal combustion engine systems, for vehicle applications. Current heavy duty diesel technology is demonstrating, in production, better fuel economy than future goals for the automotive gas turbines. Furthermore, materials and lubricants advances required to improve the gas turbines would, if applied to diesels and other internal combustion systems, generate even greater improvements. It is very appropriate, therefore, as these results evolve, to begin to use the gas turbine programs as test beds for technology development such that R and D results will be of basic utility to a wide variety of existing and emerging energy systems. This is the approach that DOE is currently taking and it should be supported.

I realize that I have been vague in responding to your question 3, and I apologize for this. Again, I hope to correct this (within the next 30 days?). In the meanwhile, I will be glad to respond to other questions that this letter might raise for you.

I would also like to extend an invitation (to you or to key members of your staff), to visit us at Cummins. If you decide to accept this invitation, we would enjoy the opportunity to brief you on our technology and approaches to meeting (beating) the foreign competitive threat.

Yours truly,

J W Patten

J.W.Patten/pi-50183
Phone: 812 377-7233
DOC 5018W

Executive Engineer - Materials
Engineering

Mr. Fuqua. And thank you, gentlemen, very much for being here today.

[Whereupon, at 1 p.m., the hearing was adjourned.]

[Additional statements submitted for the record follow:]

PMAA PETROLEUM
MARKETERS
ASSOCIATION OF
AMERICA
Representing Independent Petroleum Marketers

Petroleum Marketers Association of America

Before the

March 6, 1986 Hearing of the

Subcommittee on Energy Development and Applications

Committee on Science and Technology

U.S. House of Representatives

Statement Advocating a

Conservation R&D Program for Home Heating Oil

Petroleum Marketers Association of America
Before the
March 6, 1986 Hearing of the
Subcommittee on Energy Development and Applications
Committee on Science and Technology
U.S. House of Representatives
Statement Advocating a
Conservation R&D Program for Home Heating Oil

PMAA very much appreciates the opportunity to describe its concern over the proposed lack of funding for oil heat R&D in the Department of Energy's budget request for Fiscal Year 1987.

PMAA is a national federation of 41 state and regional trade associations representing 11,000 independent marketers of petroleum products, equipment and service. While almost all of these marketers are small businessmen, collectively they sell over three quarters of the home heating oil and half of the gasoline consumed in America today.

Example of R&D Benefits for Consumers

PMAA believes that federal research has been very beneficial to consumers of oil heat. For example, the oil heat program that was started in 1978 at Brookhaven National Laboratory is one of the most successful stories in federal research history. With an R&D investment of only $5 million, Brookhaven demonstrated the success of the flame retention burner that has become the industry standard for new oil heating equipment.

New flame retention equipment and retrofit devices for existing oil burning equipment are estimated to save consumers $1.5 billion through reduced oil usage by the end of the next decade. This amounts to one of the best cost/benefit ratios ever funded by DOE.

Proposed Oil Heat R&D

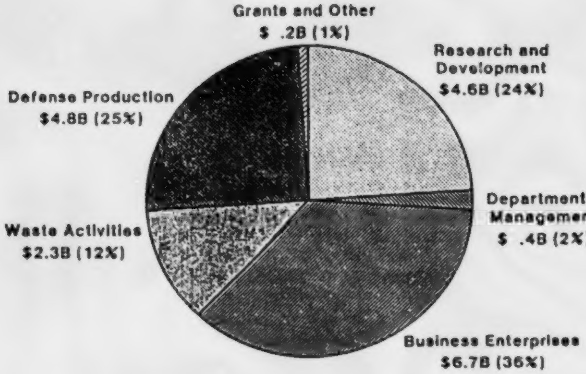
PMAA feels that there are several research projects that should be undertaken by DOE in FY87 that are equally as promising in terms of costs and benefits to 15 million oil heat taxpayers as the example just cited. These projects have been identified in a study being funded by DOE through Batelle Pacific Northwest Laboratories.

Attached to this statement is a detailed description and proposed funding level for these projects, which are summarized on the fourth and last page of this statement. Briefly, a total funding level of $1.9 million is required in three areas of activity:

- First, $1.05 million for efficiency advances on equipment such as heat exchangers and venting systems
- Second, $650,000 for advanced combustion and control, including pulsed combustion oil heating equipment
- Finally, $200,000 for technology transfer programs.

Oil Heat Slice of the Budget Pie

PMAA is aware of the Gramm-Rudman limitations on the budget, and supports efforts to reduce the deficit by reductions in federal spending. However, the pie chart on page 3 of DOE's Budget Highlights reveals Total Budget Resources of $19 Billion for DOE in FY87.



Total Budget Resources $19.0 Billion

The pie chart shows that the $.2 billion budget category of "Grants and Other" is barely visible as a 1% slice of the total budget pie, and that is over 100 times larger than PMAA's $1.9 million request for oil heat. This raises the question why taxpayer dollars are supporting DOE's multi-billion projects to produce electricity and natural gas from nuclear energy and coal, without any effort toward helping taxpayers as a user of oil heat.

Federal Role is Needed

The federal R&D for other fuels augments the work of the Gas Research Institute and the Electric Power Research Institute, which are funded by hundreds of millions of dollars in surcharges on electric and natural gas rates that are approved by federal and state authorities.

By contrast, local oil heat marketers have no exclusive sales territories and no government approval or means to impose R&D surcharges. Major oil companies, which produce and refine oil products, do not accept responsibility for any R&D activities on behalf of equipment manufacturers or any end users, including space conditioning, automobiles or airplanes.

Most manufacturers of oil heat equipment also make gas and/or electric appliances. With a relatively smaller sales potential in oil, it is understandable that equipment manufacturers commit their limited resources to the gas and electric equipment that is the focus of the government and utility research efforts.

Considering the Administration's policy calling for a balanced and mixed energy picture, Congressional support for this request would encourage an effort by DOE to develop a coordinated equipment R&D program for oil heat.

Budget Limitations

PMAA recognizes the budget limitations which are prevalent throughout the government, and PMAA supports efforts to reduce the deficit by reductions in federal spending. However, if DOE is going to continue any R&D programs at all, then it is only fair to the 18% of American taxpayers who heat with oil that oil heat get its tiny slice of the R&D budget pie. PMAA strongly urges the support of this Subcommittee for a necessary portion of DOE's total budget to continue an oil heat program with such an excellent and beneficial track record.

Research & Development Program For Oil Heat Technology

The following projects are critical to oil heating equipment technology R & D and can be initiated by DOE in FY 1987:

	Proposed Budget ($ thousands)
1. Equipment Efficiency Advances	$1,050
• Fuel Quality Variation and Combustion Efficiency (200)	
• Advanced Heat Exchangers (375)	
• Oil Burner Diagnostics (275)	
• Improved Venting Systems (Direct Vent)(200)	
-Development of the technical basis for high efficiency equipment applications to reduce heat loss	
-Reduction of institutional barriers	
2. Advanced Concepts: Combustion, Modulation and Dynamic Controls	$ 650
• Advanced controls for oil-fired heating systems	
• Improved oil burning technologies	
• Advanced combustion systems research, including pulsed oil heating equipment	
• Systems integration	
3. Technology Transfer	$ 200
• Technical training aids	
• Conferences/Symposia/Workshops	
• Accelerate the use of energy conservation options by establishing a consumer-oriented informational program	
TOTAL FY 1987 Budget	$1,900

Attachment for March 6, 1986 Statement by PMAA

Research & Development Program For Oil Heat Technology

RESEARCH PROGRAM

This section discusses a program addressing major research questions as identified by workshops, special planning surveys, and a considerable amount of past work done by related Department of Energy programs and by the American Petroleum Institute in the 1960's. This section outlines the research approach and research program.

APPROACH

The oil-fueled equipment technology project outlined here is meant to complement private sector initiatives. Operationally, this means maximizing industry involvement, with DOE national laboratories serving in management, testing research roles, and universities providing critical knowledge and fundamental research as well. Industry involvement is important for three reasons. First, industry is the appropriate place for hardware research, and a majority of the technical questions to be answered about oil-fired equipment involve working with hardware. Second, transfer of technology to industry is far more effective if industry is involved with the work from the beginning, either performing research or observing and providing feedback. In this project, each research area will include work on transferring the technology, starting from the early stages of work. Finally, there are a great many codes and standards applicable to oil-fired equipment, many of which can even affect applied research decisions. Manufacturers, who are well aware of these pitfalls, must help in generating awareness of such institutional and market factors.

The DOE national laboratory involvement covers the full range from basic research to doing tests on conceptual hardware. Most important, though, is their role as research managers: making sure the right projects are being done, and by the right people. In this project this role is especially important as much of the technological advancement will be borrowed from related fields, including both basic research fields and work done on gas heating equipment. The multiprogram national labs have the unique ability to work across fields in this way, and to make this approach effective.

This university involvement will be stimulated by well-thought-out requests for proposals and cooperation originating at DOE national laboratories. Not only will the university research directly aid in development of new technology, but the training of graduate and undergraduate students in the field will upgrade the technology in the long term. Universities are an integral part of this program.

RESEARCH ELEMENTS

This section consists of program descriptions for 8 research elements, grouped into three major areas: equipment efficiency advances, advanced combustion and control concepts, and technology transfer and education. This grouping is primarily for the sake of understanding, rather than managing, the program, as each of the research elements is quite complex and addresses fundamental problems with current oil-fired equipment and its use.

A) Equipment Efficiency Advances - this area loosely groups research areas immediately relevant to current equipment stock as well as future generations of oil-fired equipment. Work in these areas is expected to produce important results sooner than the more conceptual work in the next grouping.

Improved Venting Systems

Conventional oil-fired heating systems use a chimney for venting combustion product gases outside of the building. These chimney exhausts cause excessive heat losses, representing a significant efficiency loss, which could be avoided by developing alternative venting methods. Alleviating this loss may raise overall efficiency by 20% . Perhaps more importantly, new classes of high efficiency heating systems, which have lower exhaust temperatures, require the development of direct venting. Other aspects of such systems are being developed in other research elements in this paper. Primary research activities in this area include examining specific institutional and technical venting requirements and technical approaches, investigating the technical problems and application limits, and studying selected problems in the laboratory.

Advanced Heat Exchangers

Conventional heat exchanger designs for residential and commercial oil-fired boilers and furnaces predate the rapid fuel cost escalations of recent years. These designs result in significant heating efficiency loss during both steady state and transient operation. Many of these design shortcomings can be improved by applying advanced heat exchanger design principles toimprove efficiency while reducing the size and cost of oil burners and furnaces. Combinations of such improvements could raise current equipment efficiencies by as much as 10% -- a cut in losses of 50%.

Performance improvements envisioned for future heat exchangers include:

- enhanced heat transfer rates and smaller exchangers
- low-mass construction for minimal heat storage
- variable heat output rates compatible with zoned distribution and other strategies where only part of the structure needed be heated at certain times.
- reduced flue gas temperatures, and even condensing flue gas operation to recover some of the latent heat of vaporization of the combustible gases.
- lower equipment costs for same or higher efficiency performance
- heat exchangers compatible with advanced pulse, catalytic or other combustion systems

Research leading to these improvements will examine innovative heat exchange processes and devices. Some of the fundamental problems to be tackled include pressure drop/heat transfer tradeoffs, flow stability, corrosion, new exchanger materials and construction methods, noise levels, and soot deposition.

Oil Burner Diagnostics

Ideal stoichiometric combustion requires that exactly the correct quantity of air (oxygen) is supplied to completely burn all the fuel. This theoretical condition rarely occurs in practice because some excess combustion air is required as a safety factor to compensate for incomplete fuel-air mixing, changes in air density and other uncontrolled variables that exist in real combustion systems. Oil burner flames are particularly complex and require special attention to assure that adequate combustion air is supplied by the burner to prevent smoke production. Adjusting oil burner air supply to produce low smoke levels is very important to prevent efficiency degradation in boilers and furnaces and it represents a delicate balance between smoke formation and excess air. This optimum setting varies with burner design features and is determined in the field during oil burner installation and periodic servicing. If all burners were operated optimally all the time, the substantial losses currently suffered because of degradation in operating efficiency could be minimized.

Advanced combustion diagnostics and smoke measuring techniques will form the technical basis for several important applications including:

- improved field test devices to permit achieving highest possible burner efficiency;
- in-flue monitoring/alarm devices to alert homeowners and building operators of the need for burner adjustment;
- possible automated feedback controls for residential and commercial burners;
- tools for development and proper maintenance of future low input and variable firing rate concepts, which require very precise adjustment and control.

These diagnostics will be developed by borrowing from techniques pioneered in fundamental combustion research at universities and national laboratories.

Fuel Quality and Efficiency

Fuel oil properties can have an important impact on fuel atomization, vaporization, combustion, thermal efficiency and emission of pollutants. Unfortunately fuel properties vary depending how and by whom they are made (cheap imported fuel oil, for instance, is typically of very low quality), and can also degrade during storage. Problems caused by this range from efficiency losses to equipment malfunctions and breakdowns. In addition, Department of Energy research indicates that there will be continued slippage in oil properties as crude feedstock becomes rarer and of lower quality.

Physical properties of importance to combustion efficiency include viscosity, distillation temperature, pour point, carbon residue and flash point. These depend on the detailed makeup of the oil, which is a variable mix of a large number of chemical fuels and trace elements. Even if physical properties stay the same, chemical differences (such as extra trace heavy metals) can degrade performance badly.

Research will quantify the effect of certain fuel quality parameters on fundamental fuel oil combustion processes. Key research elements include investigations of effects of fuel property and chemistry changes on atomization and vaporization, mixing, and smoke production, application of these studies to burner designs, and evaluation of effects of storage on efficiency and pollutant emissions.

B) Advanced Combustion and Control Concepts - this area includes work of a longer term, more fundamental nature that the previous grouping, and includes concepts for new generations of equipment. Some of the work, particularly in control of equipment, is clearly relevant in the shorter term as well, however.

Improved Oil Burning Technologies

Fuel oil combustion is a complicated combination of physical and chemical processes that convert the chemical energy contained within the fuel into heated combustion gases. The sequence of important physical phenomena occurring at the burner include fuel atomization, fuel vaporization, supply of combustion air, fuel-air mixing, air swirl and recirculation, flame stabilization, and complete combustion reactions. This research element consists of a number of generic studies in this area; they actually underlie some of the other research elements, and form the technical basis for developing burners with improved performance.

Specific technical goals for improved burners include:

- improved thermal efficiency
- lower smoke levels
- reduced fuel firing rates
- variable fuel firing rates
- reduced sensitivity to fuel quality variations
- increased flame stability
- decreased pollutant emissions
- improved reliability
- lower maintenance requirements

Key research elements that will lead to a better understanding of fuel oil combustion processes and equipment include atomization research, fuel-air mixing studies, and the effect of combustion transients on overall performance with particular emphasis on smoke control techniques applicable to burner design. The research will be conducted as a combination of closely controlled laboratory-scale work and testing in experiments that simulate actual operating conditions.

Advanced Combustion Systems

New combustion processes such as puse and catalytic combustion hold great promise for improving the efficiency of oil heating systems and permitting the development of a new generation of heating equipment designs. They should permit more complete combustion, reduced pollutant emissions, enhanced heat transfer rates, lower on-cycle and off-cycle heat losses, and reduced equipment size and cost. Pulse and catalytic systems for natural gas have been introduced recently, as the products of considerable research. The pulse systems have substantially higher thermal efficiency than conventional systems, while the catalytic systems permit new operational concepts such as zone heating systems distributed through a building. Development of such systems for oil though, involves solving further and perhaps more difficult research questions.

Research in this area will explore these new system concepts through development of computer models, design approaches, building of conceptual devices and characterizing them for important functional parameters, and further identifying benefits and drawbacks of such new approaches. For instance, the real potential for pulse oil-fired systems may be as a condensing flue gas system -- an incredibly efficient combination in which some of the problems of condensing operation are mitigated by the benefits of pulse combustion and vice versa! This work may utilize results from several of the other research elements, particularly diagnostics, heat exchangers and oil burning technologies.

Improved Control Strategies

Conventional control systems and strategies have not benefitted from recent advances in sensors, microprocessors and systems engineering. Burner on-off cycling causes significant heat loss during the burner off-period that reduces the overall seasonal heating efficiency of the unit. Because burner modulation is impossible with current designs heating systems turn on and off far more than ideal, and cannot be adjusted to only heat occupied portions of a building. Improved control of combustion equipment, once combined with knowledge of building and distribution system thermal control, will lead to up to 40% fuel savings, particularly when combined with improved burners that permit modulation.

Research needs for control strategies include work to understand the way buildings and their occupants interact with equipment as well as work on the best way to control the equipment itself. The former work is part of a separate ECEP project, especially insofar as it is independent of the type of cooling or heating equipment involved. Research areas under investigation here include strategies for controlling equipment based on the thermal and mechanical behavior of the burner, heat exchanger and other parts of the equipment. This requires measurement of thermal time constants of components and correlating these with heat losses in order to develop guidelines for the best possible control strategies.

C) The final grouping is critical for this type of large, multifaceted research effort, and has thus been put in a separate category. Actually technology transfer is an integral part of every research area discussed above; this effort has additional goals and funding over and above such work.

Education/Technology Transfer

Conventional oil-fired systems, though technically simple, require considerable attention in order to perform at their best. Although their best is not very good, the level at which they actually perform given haphazard and ill-informed attention is much worse. In the near term, as much as 25-30% fuel savings can be reached by simply coordinating educational efforts of the heating oil community. Department of Energy involvement, for instance, means a great deal, and costs very little. In addition, such efforts give researchers valuable contacts within the user community that are the key to providing usable, effective new concepts.

These contacts will help facilitate technology transfer as research results are achieved, as it is axiomatic that the best transfer occurs between industrial and research practitioners rather than managers. Key educational and technology transfer activities will include a large number of laboratory visits, production of special documentation, and holding industry workshops. All such efforts will be tied to specific technical research elements outlined here.

PROGRAM RESOURCES AND MANAGEMENT

This section outlines possible program management and preliminary resource plans.

MANAGEMENT

The liquid-fueled equipment project should become one of several key elements of the Energy Conversion Equipment Program (ECEP), which is in the Office of Buildings and Community Systems in the Department of Energy. A decentralized management plan is used in ECEP, whereby the technical resources of the national laboratories are used for program management functions and performing research, while program direction and policymaking is the responsibility of DOE headquarters.

Brookhaven National Laboratory should have program management responsibilities for this oil-fueled equipment research. Brookhaven will issues Requests-For-Proposals, evaluate proposals, execute contracts and monitor contractor performance, and otherwise perform the bulk of the interaction with universities and manufacturers. It will also perform a variety of in-house research which it is best suited to do, and coordinate technology transfer on work done in-house and by others. Finally, Brookhaven will continually interact with DOE headquarters, serving as the primary information channel for program control as well. This activity is typical for ECEP and other DOE research programs.

RESOURCES

This project as outlined will develop a large number of improvements to current capabilities of oil-fired equipment and its use. Some of the planned improvements should be completed within one or two years; others will take longer. All work is expected to take place within a funding scenario of approximately $2 million per year in real dollars. Funding on specific research elements is expected to shift somewhat as various stages on the various elements progress and trade off against one another. The possible FY87 funding split is shown on the following page.

FEDERAL R&D ON ENERGY EFFICIENCY
A $50 BILLION CONTRIBUTION TO THE U.S. ECONOMY

A White Paper on the Consequences of Proposed FY 1987 Budget Cuts

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PART B: CASE STUDIES OF R&D ON ENERGY EFFICIENCY IN THE BUILDING SECTOR

This section recounts the development of seven energy conservation technologies in lighting , windows, and appliances. In hastening the commercialization of these technologies by two to five years, federal conservation R&D will save U.S. consumers $68 billion over the next 25 years.

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SUMMARY

Part A of this White Paper explains the compelling economic and security reasons for maintaining federal energy conservation R&D at least at current funding levels.

If Americans consumed as much energy today per dollar of GNP as they did in 1973, the U.S. would in 1986 be importing four times as much oil as we are now and spending an extra $150 billion per year for energy. Our trade deficit would be far worse, oil prices would have stayed high due to extra U.S. demand, and OPEC would still be a dominant force, weakening our national security and our strategic position in the Middle East. Federal programs in conservation R&D have played an important role in bringing about the $150 billion in annual savings we currently enjoy and in strengthening our economic and strategic position. Moreover, government studies show that by implementing additional efficiency measures that are cost effective at today's energy prices, the U.S. can improve its energy efficiency by 30% and save an additional $130 billion per year.

Continued federal support is needed to foster the development of new conservation technologies that will make the nation more efficient at home and more competitive abroad. Through public-private partnership, federal conservation R&D programs are stimulating efforts that industry would not undertake alone. These programs have already paid off handsomely. In Part B of this White Paper, we give seven examples of R&D successes in buildings components and equipments. By "success" we mean that the improved technology is already at or near commercial production, and will achieve 50% market penetration five to fifteen years. We can then evaluate the annual savings at market saturation, which occurs roughly 30 years after project initiation. Just these seven examples will save U.S. consumers $18 billion/year (scaled to today's economy). Since the federal role advanced this $18 billion/year by 2-5 years, we estimate that the cumulative savings attributable to DOE R&D are worth $68 billion.

The payback calculations do not attempt to estimate any additional secondary benefits which may derive from the resulting enhanced competitive position of U.S. manufacturers or from increased national energy security. Many other equally impressive success stories could be recited due to conservation research in the industrial and transportation areas. In the future we plan to add other case studies in these areas.

A typical feature of these seven cases is their low cost of conserved energy, i.e., the cost of providing the desired service by improving efficiency instead of purchasing electricity or gas. The cost of conserved electricity ranges from 1 to 3 cents/kWh vs. about 10 cents/kWh for new power today; for natural gas cost of conserved energy ranges from $2-3/MBtu vs. $6/MBtu for retail gas today. Thus, conservation has been running 2 to 10 times cheaper than new supply.

An important common element of each of these seven cases is the early involvement of private sector firms, generally through subcontracting. In most instances, private firms did most of the development. Often small businesses (sometimes very small) played a key role. They did the early development, and when the innovation was at the stage where it looked good commercially, it was picked up by larger firms through buy-out or partnership. The government R&D efforts were the catalyst in this public/private sector partnership, supplying the financial resources, technical support, and independent evaluation through the national laboratories. This support was sustained over a sufficiently long period of time that successful market entry occurred. process could be completed.

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LIGHTING

Energy-Efficient Solid-State Ballasts for Fluorescent Lighting

In 1976 the U.S. Department of Energy (DOE) established a lighting research program at the Lawrence Berkeley Laboratory (LBL) to accelerate the commercialization of energy-efficient lighting technologies. LBL researchers under the direction of Professor Sam Berman soon focused on the potential of solid-state ballasts powering fluorescent lamps at high frequency to reduce the energy needed for lighting by 15-30%. Calculations showed that if such high efficiency ballasts were to saturate the U.S. market they could save $5 billion per year by reducing energy demand by an amount equal to the output of 10 large (1000 MW) power plants.

None of the major ballast manufacturers showed any interest in the program or replied to a request for proposal (RFP) that LBL issued in 1976 for cost-sharing subcontractors to develop circuitry for the ballasts. However, about 14 small, entrepreneurial firms did apply. This pattern appears in many of the R&D case studies discussed in this document. Large established firms showed little interest in the early stages of product development, whereas small companies jumped at the opportunity to conduct joint R&D with the government. It appears that modest federal funding helped speed valuable research that large firms would not have pursued on their own initiative and which small firms working alone could not afford. The results of this public-private partnership are impressive, both for the energy savings potential they have provided to society and the business successes they generated.

In 1977 LBL selected two contractors to develop prototypes. IOTA Engineering submitted a low-cost, non-dimmable design; Stevens Electronics submitted a sophisticated high-performance design that was not only more efficient, ~~but~~ could also dim the fluorescent lamps down to 10% of full light output.

The first prototype delivered to LBL for testing showed that the new high frequency ballast could increase lighting efficiency 25%, by combining 15% better lamp performance with reduced transformer losses from the ballast itself. The first generation ballasts were not reliable enough, however, so LBL arranged to have a second generation prototype developed and installed for demonstration and testing at the headquarters of the Pacific Gas & Electric Company (PG&E) in San Francisco. The federal laboratory's involvement in this research lent the credibility needed to get a major demonstration program approved at such a highly visible location.

At PG&E in 1978, 500 IOTA ballasts were installed on one floor, 500 Stevens ballasts on a second, and 500 energy-efficient electromagnetic ballasts on a third. LBL monitoring confirmed that the new ballasts reduced lighting energy consumption by 25% without compromising illumination requirements. However, a considerable number of ballasts failed due to design faults that had not been identified in limited laboratory testing.

In 1979, after the design problems were corrected, commercial interest in the ballasts increased. Beatrice Foods, Inc., bought IOTA's concept and patents rights and formed a division, EE Tech, to develop and produce the product. Stevens Electronics sold their exclusive rights to Luminoptics, a company established to manufacture and market the Stevens design.

In 1979, the Veterans Administration Office of Construction proposed to co-fund with DOE a demonstration of the advanced dimmable ballast prototype in a medical center in Long Beach, CA. LBL placed over 400 ballasts supplied by Luminoptics in the medical center, measured their energy savings and reliability, and studied their compatibility with personnel and equipment. After this successful demonstration, the Veterans Administration Office of Construction became the first federal agency to specify the use of solid-state ballasts.

Throughout this period LBL published its findings and made numerous presentations to the lighting community and general public. Major U.S. ballast manufacturers continued to show little interest, although two foreign companies, O.Y. Helver (Finland), and Toshiba (Japan), began producing solid-state ballasts in 1980. From 1980 to 1984 a dozen small domestic manufacturers struggled to establish a market for high efficiency ballasts and to improve the reliability of their products. The relatively conservative lighting industry was slow to adopt these innovative designs, even though foreign firms were already entering the domestic market with energy-efficient lighting products. LBL's program support was reduced during this period, but it continued to publicize the benefits of solid-state ballasts and to test the new products for reliability. LBL also worked with the manufacturers and the Federal Communications Commission to develop voluntary standards to assure that electromagnetic radiation emitted by the high frequency ballasts would not interfere with computers, communications devices, and other electronic equipment.

By the end of 1984 one million solid-state ballasts for the F40, 40-watt lamp had been sold in the United States. Though this was a small amount in comparison to the total annual demand of 70 million units, the proven credibility of the products, in concert with LBL's R&D support, information dissemination, and technology transfer had finally brought the solid-state ballast to the brink of commercial success.

In 1984 General Electric and GTE announced a lamp that was designed to be operated with a solid-state ballast. This signified that the major lamp manufacturers recognized that an important new market was emerging. In 1985 General Electric announced a solid-state ballast, and Universal Manufacturing announced a low-cost dedicated solid-state ballast. Advanced Transformer, the largest U.S. ballast manufacturer, has just announced plans to market a solid-state ballast for two 40-watt, F40 fluorescent lamps. Small companies are still entering the field expecting to obtain a market share for special applications. The market for solid-state ballasts is expected to grow rapidly, and should achieve 50% penetration by 1990 and saturation by the year 2000.

The successful strategy and perseverence of the LBL/DOE program, with the coordinated and cost-shared investment of small companies have created a new, efficient lighting technology. The DOE funding for this program over the past nine years was only $2.7 million, approximately half of which was subcontracted, with subcontractors providing an additional $1 million.

Today, two million solid-state ballasts are in operation in the U.S., each saving on the average 25 watts for 4000 hours annually, a total of 200 million kWhs. At a typical energy cost of $0.075 per kWh, this reflects an annual savings of over $15 million: the $2.7 million DOE investment in the solid-state project has already been returned five fold. Within 30 years, the cumulative net savings from the government's participation will total approximately $25 billion. This achievement reflects how an effective DOE strategy to promote technological innovation can succeed even in a restricted environment dominated by a few large corporations with a seemingly captive market. The 1980 foreign import threat appears to have been repulsed.

Future Possibilities

The high-frequency solid-state fluorescent ballast is the key technical element allowing the more widespread application of demand control of the light output of fluorescent lamps. While standard core ballasts can dim fluorescent lamps by conditioning their input power (voltage reduction or phase control), solid-state ballasts dim lamps by low-voltage signals. This reduces the cost of the control equipment and increases the flexibity of the control system. That is, solid-state ballast control systems independently dim single lamps as well as large banks of lamps. Electromagnetic ballast systems, in contrast, can dim only large banks of lamps and at greater expense.

Thus, in addition to demand preferences, such as scheduling and lumen depreciation strategies that bring the energy savings to 30-40%, solid-state ballast dimming systems can effectively employ task tuning and daylight capture, as well as load-shedding strategies. The latter strategies can reduce energy consumption by another 30-40%. The total cumulative energy saving, considering the intrinsic gain and all the other demand strategies, has a potential savings of 60-70%, or more than double that of the best core ballast dimming system.

Cost of Conserved Energy is calculated in the last section of Part B.

WINDOWS

Advances in High-Performance Windows
The Successful Development of
Low-E Coatings for Windows

One quarter of all the energy used to heat and cool U.S. buildings—an amount equal to the entire output of the Alaska pipeline—is required to compensate for unwanted heat flow through windows. Windows were perceived as weak thermal links relative to insulated walls and roofs, and the first building energy guidelines developed in response to the energy crisis responded to this perception. In addition to requiring greater use of double glazing, their intent was to reduce window area, regardless of desires for windows in living and working spaces. The crisis-oriented prevailing wisdom assumed that the only way to save energy was to sacrifice amenity and comfort.

Recognizing this, in 1976 the U.S. Department of Energy (DOE) initiated a program at Lawrence Berkeley Laboratory (LBL) to develop guidelines for more efficient use of windows and to develop more energy-efficient window components and window systems. LBL researchers, under the direction of Stephen Selkowitz, set out to develop a window that would look like a window, admitting light, views, and useful solar heat gain but behave thermally more like an insulated wall. They calculated that if a selective window coating could be developed that was transparent to visible light and solar radiation but blocked heat flow, energy loss through windows could be dramatically reduced.

In 1976 the principle behind such low-emissivity (low-E) coatings was understood, but no commercial low-E products were available. Some manufacturers knew about the potential of such coatings, but they doubted that durable products with adequate optical properties could be produced at low cost and high volume. With other issues apparently more pressing at the time, the R&D programs of the window industry essentially ignored low-E coatings. It wasn't until the federally funded research program demonstrated the promise of this technology that the window industry began to aggressively develop and ultimately market low-E products.

The $2 million federal investment went a long way, stimulating over one hundred million dollars in private sector investment in low-E film production technology. In 1985, low-E window coatings were commercially available and saving consumers $14 million per year on their energy bills. By 1995, low-E films are expected to capture over half of the window market and yield annual heating savings of $120 million. And by the year 2000, cumulative energy savings from low-E coatings for the residential sector alone should exceed billions of dollars.

This dramatic advance in window technology began with a series of research grants that LBL issued with DOE funding to several small research firms in 1976. Their task was to investigate potential coating systems and deposition processes for low-E films. LBL undertook studies to determine the optimal use of coatings within the multi-element window system and to determine the potential benefits of these hypothetical windows in residences. Extensive conversations and meetings were held with key actors in the window industry and limited market studies were completed to better understand the fit between various window designs with low-E coatings and the complex structure of the window industry. These studies were important since the coatings were likely to be developed and sold by glass companies or specialized fabricators, while the windows would ultimately be sold to specifiers and homebuilders by the window manufacturers, who, as a group, lacked experience and confidence in sophisticated coating technology. LBL completed building simulation studies to estimate the benefits of this new technology and presented results to meetings of architects and engineers to try to build a market interest and demand for the products.

After several years of DOE research support, one of the small firms developed a coating technology to the point where they were able to attract venture capital to build their first production facility. Southwall Technologies, formerly Suntek Research Associates, was originally interested in the huge retrofit market and thus developed a low-E coating and deposition process for thin plastic films. While their initial product had excellent optical properties and achieved the initial goals for low emittance (.15) and transmittance (>70%), it did not have adequate durability to be used in retrofit applications exposed to air and dirt, so they turned their attention to a sealed window unit incorporating a coated plastic film stretched across the air space of a conventional double-glazed window. Since the window design had two air gaps, the U-value (heat transfer rate) of this window (.23 Btu/ft2-hr-oF, or more than R-4) was even better than that of a simple double-glazed unit with a low-E coating directly on the glass surface. But the use of plastic in the sealed glass unit and the additional cost and complexity of incorporating a smooth, taut plastic film stretched across the air space turned out to be a significant obstacle to rapid adoption by the relatively conservative window industry. Since high-quality windows are expected to have a lifetime of over 20 years, these durability related-questions were very important to the window firms that would be ultimately liable for the product. By 1980 Southwall was in business of producing their first-generation roll-coated product and was working closely with several window manufacturers to develop and refine the fabrication technology to incorporate the stretched film in the window unit.

In the glass industry, coatings are applied to glass by two processes. In the pyrolytic process a coating is applied directly on the hot glass as it emerges from the float glass tank. This has the potential of very low cost, but consistent control of the process parameters in the rapidly moving production line is difficult. While simple solar reflective coatings had been applied with this process, no one had developed an adequate pyrolytic process for applying the more complex low-E coatings.

Vacuum-deposited coatings are applied in a vacuum chamber large enough to accommodate a large piece of flat glass. Maintaining good coating uniformity over large areas was difficult, and in many facilities a large percentage of the coated glass had to be rejected for this reason, thus raising costs of the finished product. The low-E coatings, which were typically three-layer designs, appeared to be even more difficult to apply without an unacceptably large rejection rate.

Early in the research program, coating technology consultants to LBL reviewed various deposition processes to determine if any had the potential to deposit the types of materials required for low-E coatings at high deposition rates and with good uniformity. A process known as magnetron sputtering appeared to meet the requirements and was gaining favor in the late 1970s for small area coating in the electronics industry. The major U.S. producer of large magnetron sputtering systems, Airco Solar Products, was in the process of trying to sell these new large deposition systems to the U.S. glass industry to produce solar control coatings for architectural applications. At that time most of the large glass producers used older vacuum coating systems that could not easily produce uniform, multilayer coatings. Based in part on the promising initial results from the DOE supported studies, Airco accelerated their R&D program to develop suitable low-E coatings that could be licensed to the purchasers of their deposition systems. This was necessary because most of the U.S. glass companies did not have the resources to undertake coating R&D and none of them had deposition systems capable of producing the coatings.

By the early 1980s several large sputtering plants had been sold to major U.S. manufacturers but none were offering a commercial low-E product. In Europe, with higher energy prices, more restrictive building standards, and a tradition of greater first cost investment in buildings, several versions of low-E coatings had been successfully marketed. One of the first Airco machines was sold to Pilkington Glass Ltd. in the U.K. and installed in Sweden where the low-E coated glass was a major product. LBL participated in an International Energy Agency Task Group on window performance with researchers from seven other European countries. This provided an opportunity to learn more about the experience with low-E in other countries, to share those insights with U.S. industry, and to apply those results to the U.S. research effort.

In the early 1980s LBL staff gave presentations at industry association meetings and trade shows, and met privately with research and marketing staff from a number of major window manufacturers to build confidence in low-E technology. Extolling the virtues of this nearly invisible product with real but invisible advantages was a challenging task, particularly since major building engineering guides like the 1981 *ASHRAE Handbook of Fundamentals* made little mention of low-E coatings. LBL developed new tables of heat transfer data for low-E windows, which were published in the 1985 Handbook.

Interest and confidence in low-E coatings was advanced by their use in a small test building at MIT. The facility originally used prototype windows incorporating the Southwall coated plastic. These were later replaced with the Airco coated glass product. Since low-E windows were one of several innovative building technologies being demonstrated in the facility it was not possible to isolate the effects of the low-E glazing alone. However, it was an important step in the long process of building confidence in this technology, giving many interested parties their first view of windows with low-E coatings.

Market Breakthrough

A major market breakthrough occurred in 1983 when Airco installed a large sputtering plant for low-E coatings for Cardinal IG, the firm that supplies the sealed insulating glass units for the largest window manufacturer in the U.S., Andersen Corporation. This was the first time that a large glass coater had been operated in the fenestration industry by anyone other than a glass producer and it stimulated additional purchases of this type. Once Andersen announced the availability of a low-E window, the generic product gained new credibility in the eyes of consumers, builders and specifiers, and it placed additional competitive pressure on other window manufacturers. In 1984 the first significant sales of low-E glass occurred; by 1985 industry estimated that 70 million feet or over five percent of the market had been captured. The marketing directors for several major glass firms estimate that 25-50% of the residential market could be captured by 1990, a very high penetration rate for a new technology.

As market interest increased, glass manufacturers and others in the fenestration industry became more interested in new coated glass products and they invested in a number of the large sputtering plants at a cost of about $10 million each. By the mid-1980s industry had invested more than $150 million in facilities that could produce the new generation of low-E coatings, and virtually every major glass and window company offered a low-E product.

Although the product was originally developed with the northern residential market in mind, low-E coatings will also penetrate the residential sunbelt market and some fraction of the nonresidential building market. Traditional, high transmission low-E coatings can be modified to selectively transmit daylight but reject solar near-infrared to reduce cooling loads. In the sunbelt this offers control of winter heat loss and summer sun without excessive loss of view, and with greater comfort year round. Since most of the new residential construction is in the sunbelt, this application represents a major new market opportunity.

In nonresidential buildings these modified low-E coatings will also make it easier for architects to utilize daylighting to save electric lighting energy and to reduce peak electric demand charges. LBL simulation studies were the first to extensively explore the complex tradeoffs between daylighting benefits and heating and cooling loads and to make recommendations on the best coatings types for different climates. Results of these LBL studies were utilized by ASHRAE in revising their nonresidential building standards to recognize the potential benefits of properly designed and managed windows.

The proliferation of low-E coatings on the market is a sign of their commercial success, but it creates problems for designers and specifiers who may be overwhelmed by confusing and conflicting data. LBL worked with the National Fenestration Council to conduct a Low-E Industry Roundtable in August 1985, where over 100 industry representatives discussed mutual concerns. The attendees expressed an interest in developing standardized calculation procedures so that low-E claims could be compared on a consistent basis. A new DOE/LBL computer model that might assist in meeting this objective was released at the meeting. "WINDOW" allows users to calculate the thermal properties of low-E windows of almost any design to help manufacturers and designers make better window design decisions. Other DOE-sponsored projects are underway at the National Bureau of Standards to develop standardized procedures for laboratory measurement of window heat transfer, and at LBL to measure the performance of low-E windows outdoors in a new, highly accurate, mobile field test facility. Performance data from realistic field tests are essential to help validate simulation models of low-E performance, to develop reliable design guidelines and to gain the confidence of developers and specifiers of this new technology.

Sales, Costs and Savings

An estimated 70 million square feet of low-E windows were sold in the U.S. in 1985 at a retail cost $2.00-$3.00 per square foot more than normal double-glazed windows. These were primarily sputter coated on glass, although the coated plastic films are also selling well. Several U.S. glass companies have now introduced pyrolytic low-E "hard coats". These can be used on single glazing and in non-sealed multiple glazing units, thereby extending sales to the large retrofit market. The emittance properties of the pyrolytic coatings are not as good as those of the sputtered "soft coats", with the exception of one imported from Belgium by a U.S. window manufacturer. Additional coating research and development in the U.S. and overseas in the years ahead will continue to improve optical and thermal properties and cost factors. It should be possible eventually to reduce coating manufacturing costs to $0.10 -$0.25 per square foot which should reduce the additional retail cost to under $1.00 per square foot.

The potential energy savings from full market penetration of this technology are enormous. In the residential sector, windows with low-E coatings are now specified for new construction, additions, and renovations, a market with total annual window area sales of about 700 million square feet. The recent introduction of the pyrolytic hard coats provides additional opportunities in the retrofit market, such as storm windows and add-on glazings. The multitude of new low-E products and their varied potential applications makes it difficult to precisely predict their total energy-saving potential. It seems likely, however, that annual heating energy savings by 1995 will total $120 million[1] and that cumulative energy savings through 2000 for the residential sector alone may total more than $3 billion.

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[1] We estimate total savings based on the following assumptions: 1) Existing stock is a mixture of single and double glazing; 2) single can be replaced by single with low-E or by double with low-E; and 3) double can be replaced by double with low-E or by other multiglazed and gas-filled configurations with low-E. We calculate the improvement in heat transfer rate for each and derive an overall weighted average improvement of about 0.25 Btu/ft^2-hr-°F. Since our interest is in heating energy, we select a typical climate that is slightly colder than average. In a climate with 6000 heating degree days, the improved windows will reduce heat loss by about 35,000 Btu/ft^2-yr, which will save about 50,000 Btu/ft^2-yr after heating system efficiency (about 70%) is accounted for. At an average 1985 natural gas price of $6.00 per million Btu, the savings is $0.30/ft^2 per year. If industry projections of capturing over 50% of the residential window market by 1995 are realized and if total annual residential window sales climb slowly to 800 million square feet this would result in 1995 low-E sales of 400 million square feet, with an annual heating energy savings of $120 million ($0.30/ft^2 x 400 million ft^2 = $120 million). Actual savings will be larger since we neglect storm window retrofits and the higher value of savings in electrically heated homes and ignore potential cooling-load savings in the sun-belt. In addition, low-E glazing use in the commercial sector will further increase savings.

Summary

The U.S. Department of Energy invested approximately $2 million in research efforts to accelerate development and commercial introduction of low-E technology. This helped to leverage a much larger private-sector investment in new deposition systems and in development of new window product lines. Builders, architects, engineers, and home owners are in turn investing even greater sums to purchase and install these new systems. The ultimate benefits accrue to homeowners, in the form of lower utility bills and improved comfort and amenity; to the fenestration industry, in the form of new production technology, increased employment, and new value-added products; and to the U.S. in the form of decreased dependence on imported fuel, improved balance of payments, and maintenance of a strong building sector that can compete effectively in the international market. As individuals and as a nation it makes sound economic sense to invest in this new energy-saving technology.

Over a ten-year period the DOE-supported fenestration research program has worked cooperatively with industry to introduce a new generation of high-performance window products. The successful market introduction of windows with low-E films is important because of their enormous energy savings and because they lay the foundation for further technological breakthroughs in window designs that are the subject of current DOE-supported research.. In cold northern climates a new generation of "superwindows" will have a resistance of R-6 to R-10 and will outperform the best insulated wall or roof. In the sunbelt and many nonresidential buildings, new "smart windows" will automatically adjust their transmittance properties in response to changing climatic conditions, to energy management requirements and to varying occupant needs within the building. This will minimize cooling needs, maximize daylighting benefits, and provide the glare control, thermal comfort and privacy desired by building occupants. With these technology options and the appropriate design data to ensure their optimal use, windows and skylights have the technical potential of completely eliminating their net annual energy cost, becoming instead a net source of energy in buildings. Continued federal support of energy-efficient window research is vital to the achievement of this challenging and important national goal.

BUILDING EQUIPMENT

Introduction

The objective of the Building Equipment Research (BER) program at Oak Ridge National Laboratory (ORNL), sponsored by the Department of Energy (DOE) Office of Buildings and Community Systems, is to develop a technology base for improving the energy efficiency and load characteristics of equipment for space heating and cooling, water heating, and other appliances used in residential and commercial buildings. This program has been sponsored by DOE since 1976. During the late 1970s and early 1980s, the philosophy of DOE and its predecessor, the Energy Research and Development Administration (ERDA), had been to work on projects that showed the potential for near-term commercialization of energy-efficient appliances. As a result of the research sponsored by DOE, a number of new products were developed by manufacturers and were successful in the marketplace.

The change in administrations brought a change in philosophy within DOE, and the charter of DOE-sponsored research shifted to long-term, high-risk research with the potential for high payoffs. Under this philosophy, activities with near-term commercialization potential were phased out, and research shifted to equipment that might represent products to be introduced in the 1990s. Emphasis has been on high-risk activities that are not likely to be carried out by the private sector.

Below are five case studies. Three represent projects that were completed in the early 1980s, and resulted in more efficient products on the market. Two represent research that is currently underway and which, if successful, will result in new products in the 1990s. They represent clear cases where DOE-sponsored research was instrumental in accelerating the development of a technology. The DOE-sponsored research either produced the first product, or prompted other manufacturers to enter the market, leading to further product improvements.

Refrigerators

Under the direction of Virgil Haynes, ORNL in 1977 funded Arthur D. Little, Inc. to work with Amana Refrigeration, Inc. to design a ***high-efficiency refrigerator.*** From a list of 18 energy-saving options, six were chosen for the prototype model. These changes, including separate evaporators for the freezer and fresh food compartments, thicker cabinet insulation, improved door gaskets, relocation of the fan motor outside the freezer, and better defrost controls, were made on the existing Amana design and resulted in a 60% reduction in energy use. Twenty-five prototypes were assembled and marketed to test consumer acceptance and field performance. Response was so positive that Amana began producing the new design commercially in 1981, selling more than 16,000 units by 1983 and producing net savings to consumers of more than $200,000 per year. Other manufacturers soon followed with their own high-efficiency units.

While the Amana project was under way, ORNL also funded the Kelvinator Compressor Company to develop and field test 20 units of a prototype, high-efficiency refrigerator *compressor.* Since the compressor accounts for 70-85% of the energy demand of a refrigerator, improvements in this component were seen as critical to the goal of markedly improving the overall appliance efficiency. By implementing several design changes in the motor and suction muffler, Kelvinator was able to increase compressor efficiency by 44%. The company manufactured 30,000 of these efficient compressors and then made a business decision to buy rather than manufacture its own compressors. Those 30,000 yielded annual savings of $350, repaying DOE's cost for the project every three years. Many other manufacturers, including a production facility in China, have since adopted similar high-efficiency designs.

Heat Pump Water Heater

The concept of a *heat pump water heater* (HPWH) is decades old, but until the 1970s energy prices were too low to justify their relatively high cost. In 1976, Energy Utilization Systems, Inc., (EUS) began to develop a residential HPWH, with assistance from DOE/ORNL beginning in 1977. By the end of 1978, EUS had completed design studies and had put 12 test units through a one-year laboratory performance evaluation. A concurrent marketing study conducted by EUS indicated that an attractively short payback time could be achieved.

A 100-unit, year-long field test was then conducted with the cooperation of 20 electric utilities. This test, completed in 1980, produced useful information on the design and operating characteristics of these units. It also showed an installed average coefficient of performance (COP) of 1.93, compared to about 0.85 for conventional electric water heaters. EUS began producing HPWHs for sale in 1980, and was the first on the market with this product. Within a year, several other manufacturers offered HPWH units, and by 1984, 15 firms had entered the market. We believe that the EUS project accelerated development of this market by two to five years. HPWH sales are still very modest, with 16,000 units sold in 1985. However, the gains have been substantial, with increases of 50% in 1984 and 33% in 1985.

Heat Pumps

ORNL has devoted about $9 million to cooperative research with manufacturers and industry R&D groups such as the Gas Research Institute and the Electric Power Research Institute to advance the efficiency of *gas and electric heat pumps.* These devices have the potential to heat and cool interior spaces more efficiently than conventional furnaces and air-conditioners. However, they rely on sophisticated thermodynamic cycles which, although practical in theory, have been difficult to engineer at low cost. ORNL has played a key role in identifying the most promising advanced designs and in supporting R&D with private firms to bring these designs to commercialization.

Because the commercial heat pump market has been highly competitive in the past, with low profit margins, major domestic manufacturers have not devoted extensive resources to improving their products. General Electric and Westinghouse have both sold their HVAC (heating ventilating and air-conditioning) manufacturing businesses, presumably because of low profitability, and Borg-Warner is in the process of spinning off their HVAC division for the same reason. Many heat pump manufacturers are consequently turning to foreign suppliers for their components.

With ORNL support, under Robert C. Devault, several U.S. manufacturers, including Trane Corp., Carrier Corp., and Phillips Engineering are on the verge of marketing ***gas-fired absorption heat pumps*** with coefficients of performance 40% greater than the best models available to date. These devices will trim $250-$300 per year from the average home's heating and cooling costs.

Electric heat pump efficiencies have recently been climbing by about 2.5% annually, but have still reached only 25% of their theoretical maximum efficiency. Led by Phillip Fairchild, ORNL is now working with several firms to help them develop variable-speed compressors, and to reduce dynamic losses in frosting, defrosting and cycling that have thus far kept advanced designs from reaching their full potential. It is too early to tell how much electric heat pumps can be improved, but the payoff from efficiency improvements already achieved is substantial.

Manufacturers acknowledge that federal R&D support has already advanced heat pump development by two to five years, yielding the prospect of $17 billion in savings when high efficiency heat pumps saturate the space-conditioning market.

Table B.1. Lead-times and Net Savings for Successful DOE-Sponsored Buildings Energy R&D Projects.

	Solid State Ballasts	Low-E Window Films	Residential Absorption Heat Pump	Advanced Electric Heat Pump	High Efficiency Refrigerator Compressor	High Efficiency Refrigerator -Freezer	Heat Pump Water Heater
1. DOE Project Duration	1976-1980	1976-1990[D]	1978-1988	1977-1986	1977-1981	1978-1983	1977-1982
2. Est. 50% Penetration of Sales	1995	2000	2001	1998	1990	1996	1995
3. Years by which DOE advanced commercialization	5 yrs.	5 yrs.	5 yrs.	2 yrs.	2 yrs.	2 yrs.	3 yrs.
4. Cost of Conserved Energy, (CCE)	2¢/kWh	$2/MBtu	$2.50/MBtu	$2.75/MBtu	1¢/kWh	3¢/kWh	3¢/kWh
5. Cost of DOE Project	$3M	$2M	$6.8M	$2M	$1M	$0.8M	$0.7M
6. Net Annual Savings in 1985	$11M	$14M	$0M	$0M	$0.4M	$0.2M	$6.5M
7. Net Annual Savings at Saturation (i.e. 10-15 after 50% penetration)	$5,000M	$3,000M	$2,400M	$2,500M	$1,100M	$850M	$3,000M
8. Cumulative Net Savings (Line 7 x line 3)	$25,000M	$13,000M	$12,000M	$5,000M	$2,200M	$1,700M	$9,000M
9. DOE Project ROI (Return on Investment, =Line 8 ÷ line 5)	8,000: 1	7,000 : 1	1,500 : 1	2,500 : 1	2,000 : 1	2,000 : 1	13,000 : 1

Notes:

A. All dollar savings in energy costs are net of increased costs for purchase of the improved equipment (ballast, window, etc.).

B. Line 4. Cost of Conserved Energy, CCE. We use a real discount rate $d = 7\%$, and the useful life of the product: e.g. - 10 years for ballasts, 20 years for windows. The CCE of low-E films, now still a novelty, is currently $4/MBtu, but as the market matures, we estimate that the CCE will drop to $2/MBtu.

C. Line 7. Net Annual Savings at Saturation are in 1985$, uncorrected for: growth in the building stock, changes in real energy costs, or discounted future values. We decided not to account explicitly for these three factors, since all three are uncertain and their combined impact probably small, as shown by the following calculation. To translate savings in 2000 or 2010 to 1985 terms, one multiplies by: $\exp[(g + e - d)T]$, with the following annual rates:

$$\left.\begin{array}{l} g = \text{growth rate of building sector (3\%)} \\ e = \text{real price escalation for electricity or fuel (1-2\%)} \\ d = \text{real discount rate (4-7\%)} \end{array}\right\} \quad g + e - d = (-3 \text{ to } +1\%)$$

T = years between 1985 and the est. saturation date, 20 - 25 years.

D. As indicated on line 6, 70m sq.ft. of first generation soft-coat were already installed in 1985, but this soft-coat can be used only between sealed double glazing. Current R&D aims to increase the durability and applicability of sputtered coatings and to produce additional engineering data to better utilise the coatings in sunbelt climates and in commercial buildings.

Source: See case studies.

Table B.2. Summary of Building Conservation Case Studies.

		Solid state ballast[a]	Low-E window films[b]	Residential absorption heat pump	Advanced electric heat pump	High efficiency refrigerator compressor	High efficiency refrigerator/ freezer	Heat pump water heater
1.	Annual energy savings (Btu/unit or kWh/unit)	100 (133)[a] kWh	50,000 Btu	26×10^6 Btu	48×10^6 Btu	162 kWh	280 kWh	2800 kWh
2.	Gross savings/unit (1985 $/yr)	7.5 (10)[a]	0.30	333	404	13	22	224
3.	Life (years)	10	20	20	15	17	17	8
4.	Cost premium ($)	12	1.0	800	1300	15	100	530
5.	Annualized capital[c] ($)	1.70	0.10	71	133	1	10	83
6.	Net savings/unit ($/year)	5.80 (7.75)[a]	0.2	262	271	12	13	141
7.	Simple payback (years)	2	5	2.4	3.2	1.1	4.5	2.4
8.	U.S. stock (millions)	625	18,000 ft^2	17	19	100	100	28
9.	Saturation penetration (%)	85	80	74	67	92	88	75
10.	Saturation units (millions)	600	14,000	13	13	92	88	21
11.	Net annual savings at saturation (1985 $, billions)[d]	3.5 (4.6)[a]	3	2.4	2.5	1.1	0.85	3.0
12.	Cost of DOE project ($, millions)	2	2	6.8	2.0	1.0	0.8	0.7
13.	Commercialization advance (years)	5	5	5	2	2	2	3
14.	Net project savings ($, billions)	15 (25)[a]	13	12	5	2.2	1.7	9.0
15.	DOE project return on investment	8000:1	7000:1	1800:1	2500:1	2200:1	2000:1	13,000:1

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[a] The main column of entries describes ballasts which save 25% without feedback dimming control to compensate for daylight and lamp aging. Photocells and dimmers roughly double the surcost and the savings, leaving the cost of con- served energy unchanged. We estimate that 50% of lamps will be undimmed, 50% dimmed, with average savings of 33%. These average predicted values are shown in parentheses.

[b] Unit savings and costs are per square foot of film.

[c] % real discount rate, without tax preferences.

[d] Annual savings are uncorrected for growth in building stock. See note C of Table B.1

Calculation Methodology

An energy-efficient building or appliance that costs more to buy but uses less energy is of no economic interest unless the value of the energy savings exceeds the additional cost of the investment. Here, we explain how we calculate the economics of investment in energy efficiency.

We assume that the consumer borrows the money for the efficient appliance or building and pays off the loan in a series of equal annual payments. We call the portion of his payments that covers the extra cost of greater efficiency an annual "surcost." Dividing the annual surcost by the annual energy savings tells how much the consumer is spending to avoid buying a unit of energy. We call this the cost of conserved energy (CCE), shown in line 5 of Table B.1. Where the CCE is less than the cost of buying energy, conservation makes economic sense. The formula for CCE is:

$$\mathit{Cost\ of\ Conserved\ Energy}\ (CCE) = \frac{\mathit{annualized\ surcost}}{\mathit{annual\ energy\ savings}}\ x\,(1)$$

Example:

The following example shows how the values on Tables B.1 and B.2 yield the cumulative net savings figures on line 9 of Table B.1.

Consider solid-state fluorescent light ballasts, summarized in the first column of Tables B.1 and B.2. Line 1 of Table B.2 tells us that one of these ballasts saves 100 kWh/year. Line 3 tells us that they last ten years and line 4 tells us that they cost $12 more than conventional ballasts. Are they worth the extra cost? To find the answer to this question we must first find the cost of conserved energy. Assume the $12 is borrowed from a bank for ten years at a 7% real interest rate, where "real" means net of inflation. Line 5 then tells us that the "annual surcost" (annual bank payment on the loan) is $1.70. Equation (1) then gives

$$CCE = \frac{\mathit{Annualized\ surcost}}{\mathit{annual\ energy\ savings}} = \frac{\$\,1.70/yr}{100\ kWh\,/yr} = \frac{1.7\ cents}{kWh}$$

which is rounded on Table B.1, line 5 to 2 cents/kWh. A CCE of 2 cents/kWh is far cheaper than the purchase price of electricity (7.5-10 cents/kWh). Thus, the more efficient ballast is an attractive investment. Half of the CCE entries on line 5 of Table B.1 conserve natural gas instead of electricity. The CCE is expressed in $/MBtu and should be compared with a current gas price of about $6/MBtu.

Converting Energy Savings to Net Savings

The CCE tells us that the ballasts are a good investment. Next we want to calculate our net annual savings, which is simply the energy cost savings minus the annualized surcost.

$$Net\ savings = energy\ cost\ savings - surcost$$

For ballasts, the energy savings are 100 kWh/yr (line 1, Table B.2). Assuming electricity prices of 7.5 cents/kWh, the gross savings are:

$$100k\ Wh/yr \times 7.5\ cents/kWh = \$\,7.50/yr$$

We already calculated that the annualized surcost for the ballasts is $1.70/yr. Thus

$$Net\ savings = \$\,7.50/yr - \$\,1.70/yr = \$\,5.80/yr \quad (line\ 6, Table\ B.2)$$

By multiplying the net annual savings per unit (line 6, Table B.2) by the number of units in the market at saturation we calculate the net annual savings at saturation (line 8, Table B.1).

Based on discussions with manufacturers, we estimate that federal R&D has advanced commercialization of these technologies by 2 to 5 years. Thus, the cumulative savings consumers will ultimately realize purely as a result of the government's involvement is simply the net annual savings at saturation times the number of years by which that technology was advanced through government R&D (Table B.1. line 8 x line 4 = line 9).

STATEMENT

OF

DR. F. WILLIAM KIRSCH

Director, EADC Program

for

ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE

SCIENCE AND TECHNOLOGY COMMITTEE

U.S. HOUSE OF REPRESENTATIVES

March 6, 1986

This statement discusses the Energy Analysis and Diagnostic Center program which is sponsored by the U.S. Department of Energy, Office of Industrial Programs. The FY86 appropriation for this program is $1.5 million.

Dr. F. William Kirsch is Vice President, Energy Management and Industrial Technology, University City Science Center, Philadelphia. He serves as the director of the EADC program, which has been providing analyses of energy use and recommendations for improved manufacturing efficiency in the plants of small and medium-sized manufacturers located in 27 states.

University City Science Center

Hundreds of thousands of small and medium-sized manufacturers are in business throughout the United states, located wherever they have found the right combinations of people and other resources to start up or continue an enterprise. They are often the major employers in the smaller communities where they have located, but they are found in cities and suburbs, too. Wherever the interstate highways and railroads have provided access to raw materials and to markets, manufacturers are present, providing strength and diversity to the economy of their states and the nation itself.

Small and medium-sized manufacturing plants are not merely scaled down versions of larger ones, and they do not necessarily apply technology and consume energy in the same patterns. The usefulness of much energy efficiency information is therefore limited to large plants, and that creates problems for small and medium-sized manufacturers who try to adapt pre-fabricated solutions from large plants at a reasonable cost and with assurance they will work. Therein lies the common dilemma of this kind of manufacturer: acquiring useful expert assistance is costly, and trying to cope without it is also costly. The result is a gap between competitive needs and cost-effective ways to meet them. To bridge that gap, manufacturers need an analysis of their operations and energy use that is thorough but has no further agenda. The federal government has been providing that kind of impartial analysis to those manufacturers through the Energy Analysis and Diagnostic Center program.

As the director of the EADC program I know something about manufacturers' needs and what this help has meant to them. Within the past year I have been in 194 of their plants, most often to find out how effective EADCs' services have been. At each plant I also asked whether the EADC program represents a good expenditure of taxpayers' money and 98% of them said it was.

To understand what that verdict means, it is important to know a little about how the EADC program works. Under agreement with the Department of Energy, University City Science Center manages the whole effort. Our subcontractors have been 12 universities; their engineering faculty and students have performed analyses in about 1460 manufacturing plants to date. While doing so they have proposed about 7500 specific energy conservation opportunities with a total value of about $49 million per year, at least two-thirds of which have been in manufacturing operations. Manufacturers have consistently implemented 55-75% of the energy conservation identified and cost savings recommended. We know that fact because each EADC must measure implementation of what it recommends. By verifying that information and analyzing the data, we also know that the latest results from 300 manufacturers show they will -- within five years -- earn as much as $3.80 for every dollar they have invested in energy cost saving.

* key

The benefits do not stop there. When we count the manufacturers' cost savings as incremental earnings that are taxable, the federal government also receives a good return on its EADC program support. For every federal dollar invested in the EADC program, the government receives as much as $3.60 in tax revenues on manufacturers' earnings.

* key

The EADC program has generated a variety of other benefits, even though it has not directly supported them. Here I refer to the students' first-hand plant experience that has helped them to find jobs, to the economic stimulus provided by manufacturers' purchases of energy-efficiency equipment and services from private-sector sources, and to new and revised curricula and research that enhance the education of future engineers.

My purpose in coming here today is to ask that this EADC program be continued at a fair share of its FY86 level. I recognize the need for federal budgetary restraint, but I also point out that EADCs have been indirectly generating tax revenues by helping manufacturers to reduce costs, to increase earnings, and to stay in business. By measuring implementation we have direct evidence of these benefits.

Manufacturing is a vital part of the national economy, and an overwhelming percentage of the plants are small or medium-sized. They sell products to large plants as well as to their peers (in size) and to the public. The 1980s have not generally been as good for them as many had hoped, and today they are confronted by persistent problems -- lack of export sales, competition from imports, and a need to modernize while remaining profitable. Uncertainty is their constant companion and chief enemy, and I like to think EADCs are lessening that uncertainty, or at least preparing manufacturers to cope with it better.

The manufacturers assisted by an EADC are among the strongest supporters of the program, and they add up to more than 90% of those that have been served by one. But I don't want to bask in the sunshine of their praise. My goal is to serve more small and medium-sized manufacturers -- to help them remain profitable by being more efficient, to help them stay in business by becoming more competitive.

The federal government's support is essential to fulfillment of that goal, and the government can do that while continuing to get an excellent return on its investment. I ask you to give the EADC program its fair share of the federal investment in the nation's future.

Dr. F. William Kirsch, Director
Center for Energy Management and Industrial Technology
University City Science Center
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Philadelphia, PA 19104
215-387-2255

MECHANICAL TECHNOLOGY INC.

March 10, 1986

Honorable Don Fuqua
Chairman
Subcommittee on Energy Development and Applications
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

During your hearing on March 6, you asked me a question concerning the suggested approach in my testimony and any examples I could give as to where that approach had been successful. I wish to have the following added to the record as an expansion of my answer.

> In addition to this approach having been successfully employed by DOD, NASA, and other government entities, it was also successfully used to bring the Pulse Combustion Furnace to commercial product status. In 1977, this high efficiency furnace option was available in only one breadboard prototype, similar to the status of American gas heat pump prototypes today. After the basic promise of the technology had been shown in that first prototype, multiple prototypes were built in order to work on various needed aspects of the equipment simultaneously. Cost share from a potential manufacturer was sought and obtained at this point in time, and as the multiple prototypes were developed, showing more and more promise, the percentage of the manufacturer's cost share increased. Finally, when pre-production prototypes had been developed and were ready for field and market testing, the Lennox Corporation took over all subsequent costs.
>
> Similar approaches are now being used in Japan and Europe to evolve advanced equipment to compete with American manufacturers. They have seen the success of the approach in the United States and are emulating it. Japanese gas heat pumps have been developed using a similar philosophy, and at least one Japanese company is approaching Stirling engine development in similar fashion.

MECHANICAL TECHNOLOGY INC. 968 ALBANY-SHAKER ROAD LATHAM, NEW YORK 12110 518/785-2211 TWX 710 443 8150

In summary, once the point has been reached in the laboratory where a "breadboard" prototype shows promise of achieving the needed product specifications, it is common practice to proceed to multiple prototypes, developed in parallel, to achieve such needed qualities as endurance, performance, component development, and systems integration. If we are to remain internationally competitive, we must do the same.

Thank you for including the above in the record.

Sincerely,

Lloyd R. Lawrence, Jr.
Vice President

/mf

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1791 Tullie Circle, NE • Atlanta, Georgia 30329 ☎ (404) 636-8400 • Tlx 705343 ASHRAE

Donald R. Bahnfleth, P.E.
President

Reply to:
ZBA INCORPORATED
23 East Seventh Street
Cincinnati, OH 45202
☎ (513) 421-3383

March 10, 1986

Honorable Don Fuqua
Chairman of the Committee on Science
 and Technology
U.S. House of Representatives
Washington, DC

Dear Chairman Fuqua:

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is a technical society involved in several areas of the public interest such as building energy conservation and indoor air quality in addition to the traditional technical areas indicated by its name. For a number of years, ASHRAE has worked with the U.S. Department of Energy (DOE) and has made use of the results of DOE programs in our efforts in technology transfer, in the development of ASHRAE voluntary consensus standards and in the Society's research program supported by the private sector.

Our members are very concerned about the nation's inattention to energy conservation. The public's attitude has grown lax recently in light of the current short-term surpluses in energy availability. Energy conservation is important to the future well-being of the nation, and ASHRAE places a high priority on conservation. As the Federal budget reduction activities proceed, ASHRAE urges that energy conservation not bear a disproportionate share of the cost-cutting actions.

We have just completed a two-year exercise in strategic planning of our technical activities and appropriate long-range objectives. Some of the identified programs relate to areas where DOE has Federal responsibilities. As president of ASHRAE, I am providing a brief statement indicating priorities assigned in our strategic plan in hopes that it may be useful in analyzing Federal programs and establishing priorities.

Very truly yours,

Donald R. Bahnfleth, P.E.

Donald R. Bahnfleth, P.E.
President

DRB:br

An International Organization

THE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS, INC.

WRITTEN STATEMENT
OF
THE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND
AIR CONDITIONING ENGINEERS, INC.

ON

FY87 DEPARTMENT OF ENERGY AUTHORIZATION
ENERGY CONSERVATION

Relative to March 6, 1986 Hearing
of the
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is a technical society whose objective is to advance the arts and sciences of heating, refrigeration, air conditioning, ventilation, their allied arts and sciences and related human factors for the benefit of the public. ASHRAE's technical interests extend beyond the traditional areas implied in its name to include areas which impact public policy such as energy conservation in buildings and indoor air quality, which are included in the responsibilities of the U. S. Department of Energy (DOE).

ASHRAE has recently completed a two-year effort to develop a long-range, strategic plan which has been adopted by its Board of Directors. In preparation for establishing long-range goals, national needs and available technology were assessed. In establishing and prioritizing its future directions, ASHRAE addressed some of the technical areas which relate to DOE programs and is sharing its conclusions in hopes that the information may be helpful.

The development of the Strategic Plan involved a broad cross section of the ASHRAE community whose 50,000 individual members are comprised of consulting engineers, mechanical contractors and employees of manufacturing companies, educational institutions, research organizations and government.

Importance of Conservation

The urgency for continued conservation permeates the ASHRAE study. ASHRAE applauds the President's concept that energy conservation should be viewed as an "energy resource." Current energy availability patterns may change abruptly as in the early 1970s if an international conflict erupts. In the absence of an international incident, the general trends in future energy availability can be anticipated, which permits the nation to address the problems now.

Lead times to put solutions in place are lengthy. This is certainly true in the area where ASHRAE has involvement - i.e., the building stock of the nation. An inefficient automobile will be off the nation's highways in about ten years, but an inefficient building will be in service 50 to 75 years.

In anticipating future trends, most will agree that:

(1) Traditional fossil-based energy availability will decrease significantly by the end of this century.
(2) Energy costs will increase non-linearly as supplies decrease.
(3) Total energy consumption in buildings will rise even with the construction of energy efficient buildings.
(4) Power plant capacities will be impacted by shifts to building electrification.

Therefore, energy conservation efforts in the buildings industry are very important to the overall energy picture. Buildings constructed today will be early in their useful life when significant increased energy costs impact again. Although the efficiency of an existing building can be improved, there is no substitute for a building designed initially for energy efficiency. The magnitude of the potential energy savings or unneeded consumption can be understood when realizing that approximately one third of the nation's total energy costs of about $420 billion dollars is for buildings.

In addressing the membership at the recent Winter Meeting this January, ASHRAE's President Donald Bahnfleth pointed out that:

> "It has only been 14 years since the nation was thrust into a major energy crisis. With the initial crisis relieved, the public's attention focuses on other national problems. In another 14 years, we will enter the 21st century. Energy conservation measures enacted now with the cooperative efforts of the public and private sectors will determine our energy and economic situation as the 20th century draws to a close."

Conservation offers economic benefits, promotes better environmental quality and lessens the potential for international conflict if energy supplies are threatened. In order to ease the transition to alternative fuels and prolong the availability of traditional fuel supplies as long as possible, ASHRAE assigns a high priority to its energy conservation activities and believes that every organization in the public and private sector should do likewise for the future well being of the nation.

In the 1970s, when the nation was forced to mobilize its efforts to deal with a crisis situation, the U.S. Congress enacted legislation which has resulted in significant energy savings through conservation measures. At the same time ASHRAE developed its Standard 90 "Energy Conservation in New Building Design" which was first published in 1975 in response to the energy crisis.

Standard 90 addresses conservation measures for individual building components which impact the energy consumption within the building; these components include the thermal envelope, lighting, equipment efficiency, etc. This standard has been widely used, and energy savings in buildings constructed since the mid 1970s has been estimated as high as twenty-five percent. Standard 90 now serves as a resource document for energy codes and standards in all 50 states.

Priority Research Areas

Buildings energy research is a key ingredient in ASHRAE's technical activities. Through a program of soliciting funds from the private sector, ASHRAE sponsors research projects and grants at university and other research organizations at a rate of approximately $1 million dollars per year. Most of the research is related to energy conservation. ASHRAE promotes research in the public and private sectors to develop improved materials, equipment and systems for buildings and energy-conversion processes.

In its strategic long-range plan, the Society indicates its intention to increase its level of research effort and has targeted three broad categories for emphasis:

Energy Conservation in Buildings:
Because energy cost and availability will be of concern in the foreseeable future, research must promote the effective utilization of energy.

Interface of Building Systems with Thermal Envelopes:
In the past research has been limited to building components. Today, however, it is recognized that a systems approach is required. For example, in some instances the value of an improvement in equipment performance can be enhanced by a corresponding improvement in the building envelope.

Occupant Health and Safety, including Indoor Air Quality:
Efforts to conserve energy have resulted in decreased natural infiltration and ventilation and increased problems with indoor air quality. ASHRAE, long a leader in thermal comfort research, will increase research relating to occupant safety and health from indoor contaminants to meet the profession's need for solutions to this problem of growing importance.

ASHRAE believes that the private sector should lead in many areas of energy related research, but there are some areas where support for the needed research is not available except in the public sector. In areas where the profit motive is zero, industry support will not materialize at an adequate level - two such areas are environmental research and whole-building energy research.

The building industry does not have the expertise to conduct or to evaluate health-related research on indoor environmental problems; also, since the building industry is fragmented, it cannot come together to sponsor research which involves the entire building system. These are areas in which ASHRAE believes the public sector should remain involved.

Other Goals of ASHRAE's Strategic Plan

ASHRAE's long-range plan addresses two other areas related to public-sector programs - namely energy standards/guidelines and technology transfer. ASHRAE will continue to work with government in these two areas and provide reliable technical data to government as the needs arise.

Voluntary Consensus Standards and Guidelines:

ASHRAE pledges to continue private-sector responsibility for development of industry standards and to promote acceptance of those standards by government. ASHRAE will strive for increasing participation of public-sector personnel in (1) the identification of needs for voluntary consensus standards and guidelines and (2) in the participation of public-sector technical experts in the development process as called for in the OMB Circular A-119.

In this regard the private-sector standards development activity relies on valuable input from qualified technical experts in the public sector. The public sector should maintain a cadre of qualified technical individuals who are on the "cutting edge" of technology and who have the overall national perspective necessary to guide, counsel and support private-sector initiatives.

ASHRAE in conjunction with the Illuminating Engineering Society is currently updating (with state-of-the-art technology) two of its standards related to energy policy considerations. Standard 90 is currently under revision (the original standard having been updated previously in 1980) with the goal of accomplishing an additional 20-percent savings in energy consumption in buildings. In a related area, one of the complications of tightening buildings for energy conservation is the potential threat of build up of pollutants. ASHRAE's Standard 62 "Ventilation for Acceptable Indoor Air Quality" is also in the final processes of revision.

Research sponsored by the U.S. Department of Energy is one of the technical resources upon which standards are kept current.

Technology Transfer:

Effective dissemination and application of building energy conservation technology is an important ingredient of public and private sector programs. Much of the value of research may be lost if the results are not transmitted to potential users. ASHRAE has worked closely with DOE in the transfer of technological developments into the design community where the general public will benefit.

As part of its technology-transfer activities, the ASHRAE Strategic Plan pledges that the Society will continue to provide leadership in demonstrating the effectiveness of new technology in saving energy. It will increase its activities in education and technology transfer so that a larger percentage of manufacturers, designers, builders and operators of energy-using equipment can effectively and economically apply new technology.

TESTIMONY

by

Peggy Wheeler Kainz
Public Affairs Director
National Center for Appropriate Technology

before
The House Science and Technology Subcommittee
on Energy Development and Applications

March 6, 1986

Testimony by Peggy Wheeler Kainz, Public Affairs Director
National Center For Appropriate Technology
Before
The House Science and Technology Subcommittee
on Energy Development and Applications
March 6, 1986

Mr. Chairman, Members of the Committee, thank you for this opportunity to testify. My name is Peggy Wheeler Kainz. I am the Public Affairs Director of the National Center for Appropriate Technology (NCAT). I am here to recommend a Fiscal Year 1987 DOE authorization level of $1.4 million for NATAS, the National Appropriation Technology Assistance Service. This is a reduction of $100,000 from our usual operating budget of $1.5 million due to some streamlining management of the program.

I also recommend an authorization of $300,000 to provide commercialization assistance to weatherization programs interested in moving their services into the private sector, and $180,000 to conduct video-conference training via satellite for large audiences of trainers in two weatherization problems. NATAS is capable of managing both of these new services.

NCAT is a non-profit corporation created by Congress in 1976 to transfer appropriate technologies to the American public. Our principal methods in technology transfer are technical monitoring and evaluation, technical assistance, and, information dissemination which includes publications and training. We manage federal, state, and private sector contracts in this regard. NCAT manages the Department of Energy's National Appropriate Technology Assistance Service (NATAS).

NATAS provides tailored technical information and technical assistance on renewable energy and energy conservation technologies to anyone who contacts the service through the toll-free phone number or by mail. NATAS' two principal objectives are: to help people investigate or implement conservation and renewable energy technologies, and to help innovators solve problems they have commercializing energy saving products and services.

NATAS is organized around five tasks:

1. To disseminate current appropriate technology information;
2. To provide engineering and scientific technical assistance;
3. To provide commercialization assistance;
4. To coordinate NATAS with other state and Federal activities;
5. To prepare publications for transferring technical information to the public.

A recent evaluation by Northwestern University (1986) has found that NATAS is well managed, highly regarded by the users, and very cost effective; for each federal dollar spent in providing the service, the user received approximately $5.93 in direct benefits. (See Attachment 1) This same evaluation also found that the State Energy Offices refer more technical engineering and commercialization questions to NATAS than to any other local, federal, private or government source. The very heavy reliance on NATAS by all the State Energy Offices demonstrates that NATAS is a highly regarded source of assistance by energy experts and administrators throughout the country.

The evaluation also verifies that NATAS business development services are not easily available in the private sector since the typical NATAS user is in the pre-commercialization stage. For the most part, the callers haven't yet conceptualized the right questions to ask about business start-up. NATAS helps such clients to reach the stage where they can then seek help in the private sector.

The toll-free line opened on May 1, 1984. Since that time (as of 1/31/86) NATAS has handled 13,388 requests (excluding more than 5000 additional requests for publications alone). The users of NATAS are comprised of about 65% individuals, 8% commercial/industrial, and 10% local, state, and federal government clients. Of these, 5253 users (39%) requested general information assistance, 7207 (54%) required engineering/scientific technical assistance, and 928 (7%) requested commercialization assistance. (See Attachment 2).

As the real purpose of NATAS becomes known, requests for general information are declining while requests for engineering and commercialization assistance are increasing. Thus far in FY 86, NATAS is averaging 195 requests per month for engineering assistance, an increase of 18% over the monthly average in 1985. An even larger increase is noted in the commercialization task: a monthly average of 54 requests represents an increase of 35.4% over the monthly average in 1985.

Projection for FY86 shows a marked increase in requests for NATAS. Compared to the 7,800 requests of FY85, the Northwestern study projected 9,200 requests for FY86 -- an 18% increase. Our own more conservative estimate of 8,800 requests for FY 86 represents a 13% increase. (See Attachment 3)

The most common topics of inquiry are solar thermal energy, energy efficient new building technologies and weatherization technologies. But NATAS requests also cover a broad range of technical questions, including indoor air quality, cogeneration, hydropower, biomass, wind, resource recovery, photovoltaics and industrial energy systems. (See Attachment 4)

The most common services provided in the engineering assistance task are resource/technology assessment and products/materials analysis. Assistance in securing financing and business planning are the most frequent services requested in business development (See Attachment 5).

Examples of technical engineering assistance NATAS has provided are:

o Advice on the design and construction of a wood stove thermosyphon domestic hot water system.

o Design assistance on sunspace glazing, framing, storage, foundation and moveable insulation.

o Mathematical calculations for power output of a wind electric generator.

Examples of commercialization assistance provided are:

- o Analysis and market research for an energy efficient process and machinery for applying asphalt for road repairs.
- o Analysis of working capital financing options for small windmill manufacturing company.
- o Start up guidance for residential weatherization business.

NATAS has prepared two publications in 1986. The first, Combustion Appliances in Energy-Efficient Houses, responds to a major concern of NATAS users. The second, Heating Systems: How to Decide Whether to Improve or Replace Them, is a consumer decision guide which addresses a frequent NATAS question.

A State-by-State summary (May 1, 1984 to January 31, 1986) of the number of users is included for the Committee's information. (Attachment 6)

Promotion of NATAS is carefully controlled so that requests do not exceed budget and staff capabilities. Any mention of the program in a publication or on television/radio results in increased numbers of callers. Most recently (January and February, 1986), the loss of the tax credits and discussion of the 1987 DOE budget have brought a significant increase (or more than 54%) in the number of callers requesting business development assistance. NCAT sees the numbers of NATAS users increasing almost without additional promotion.

NATAS requires $1.4 million for annual operating expenses in 1987. This is $100,000 less than the budget required in 1986. The same high level of quality service can be provided for fewer dollars because of economies of improved management systems. Operations include management of a staff of 27, the computerized data base, individual written responses to each technical assistance request, the preparation of publications and standardized information products, and monthly reports to each State Energy Office as well as DOE offices.

In order to maintain the high quality of responses provided currently by NATAS, a $1.4 million budget must be maintained in FY 1987. DOE requested $0.75 million for NATAS, but NCAT submits that this budget is primarily a reflection of DOE's cost cutting in general and that DOE does not wish to reduce the quality of NATAS service.

In addition to the $1.4 million base budget for NATAS, other needs have been identified through the program.

NATAS frequently assists managers and staffs of weatherization programs who hope to begin providing their services in the private sector. Based on calls in January 1986 alone, at least a 50% increase in requests for business development assistance by weatherization program personnel is projected. NATAS has provided several workshops on business and financial planning to weatherization personnel and has received requests for more workshops. In addition, NATAS has been asked to produce a "how to" workbook designed specifically for weatherization programs on the issues related to a transition to the private sector. Unless additional funds are provided to NATAS for these services, services to other users will be curtailed. NCAT recommends that $300,000 be added to the NATAS budget for these activities.

In addition to the annual operating costs of NATAS ($1.4 million) and the costs of expanding commercialization assistance to weatherization programs ($300,000), two major problems related to energy conservation and to national health have been identified as needing attention: moisture problems and indoor air quality problems. NCAT has conducted workshops in these areas and is willing to contribute its expertise and materials to NATAS to utilize in two video-conference training programs. Through satellite and video-teleconferencing, it is possible to conduct training workshops in many sites simultaneously. Given the savings through NCAT's contributions, it is possible to conduct two workshops (one on each topic) for trainers in DOE and State Energy Offices and Community Action Agencies, architects, builders, and other interested parties for $180,000.

These budget requests total $1.88 million. I believe that the budget for each activity is very cost-effective and would maintain the quality of NATAS technical assistance.

Thank you for your time and interest.

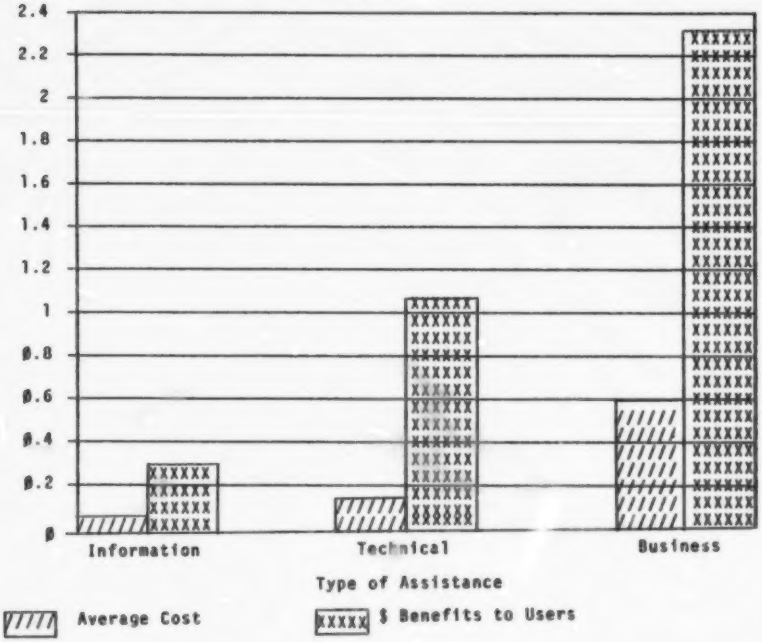
Attachment 1

DOLLAR ($) COST OR BENEFIT

(Thousands)

NATAS ASSISTANCE

Cost Benefit Analysis



Attachment 2

NATAS ASSISTANCE

Month	Informational	Technical	Commercial	Total
5/84	339	200	50	589
6/84	259	193	50	502
7/84	239	333	34	606
8/84	279	295	41	615
9/84	516	328	37	881
10/84	258	359	28	645
11/84	164	317	33	514
12/84	135	268	30	433
TOTAL	2,189	2,293	303	4,785
1/85	215	475	30	720
2/85	1,085	482	18	1,585
3/85	179	359	51	589
4/85	170	363	59	592
5/85	121	379	18	518
6/85	151	387	54	592
7/85	145	344	63	552
8/85	127	337	39	503
9/85	131	351	52	534
10/85	309	406	65	780
11/85	159	330	53	542
12/85	116	314	43	473
TOTAL	2,908	4,527	545	7,980
1/86	156	387	80	623
G TOTAL	5,253	7,207	928	13,388

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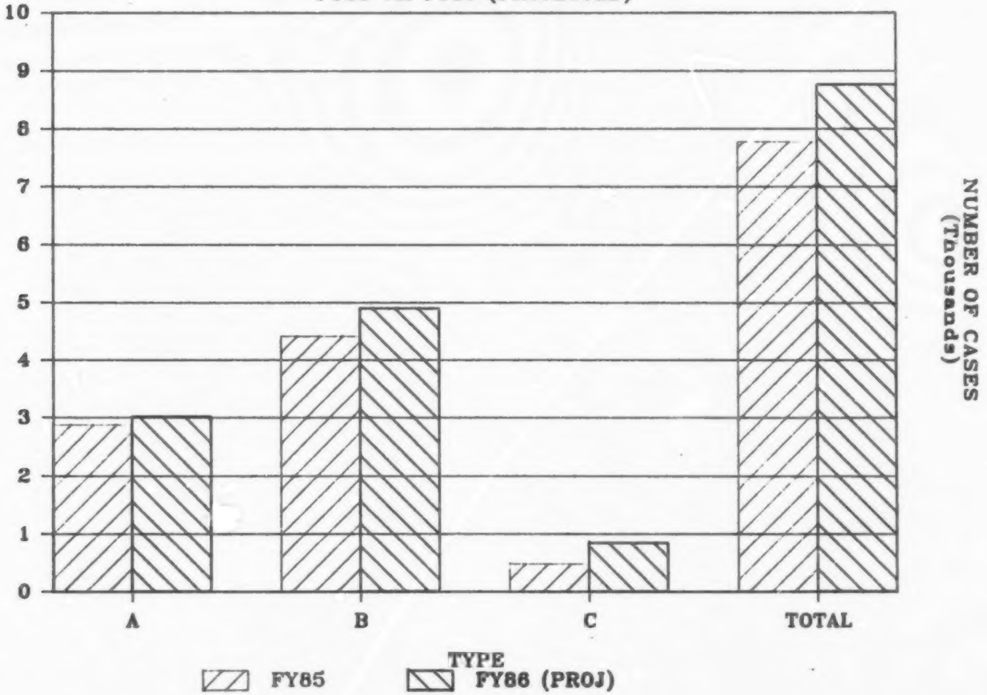
COMPARISON OF NATAS INTAKE BY TYPE

FY85 vs. FY86 (PROJECTED)



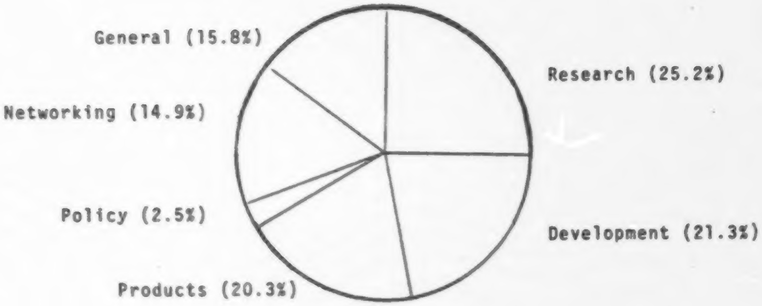
Attachment 3

Attachment 4

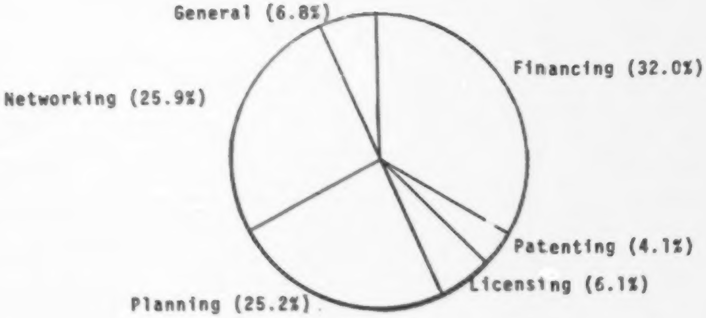
TECHNOLOGY TYPE SUMMARY
May 1, 1984 to December 31, 1985

	TECHNICAL Total to Date	COMMERCIAL Total to Date
Earth Sheltered or Underground buildings	62	10
Electrical Systems for Buildings	21	4
Energy Efficient Construction (new)	726	43
Energy Efficient Construction (retrofit)	192	27
HVAC/Mechanical Systems for Buildings	414	20
HVAC: Air-to-Air Heat Exchangers	65	0
Passive Solar Buildings	167	2
Passive Solar Greenhouse/Sunspace	443	5
Weatherization Technologies	749	57
ENERGY CONSERVATION IN BUILDINGS	2,839	168
Biomass Energy Generation	32	9
Biomass: Solid Fuels	302	10
Biomass: Liquid Fuels	85	5
Biomass: Gaseous Fuels	66	7
Fossil Fuel Conversion	55	8
Geothermal Energy	67	8
Hydro Energy Generation	159	11
Photovoltaics	203	22
Solar Thermal Energy	1,166	125
Solar Thermal: Active Systems	8	1
Solar Thermal: Passive Systems	0	0
Wind Energy	240	38
Hydrogen/Fuel Cells	20	1
ENERGY GENERATION	2,403	245
Appliances	399	34
Cogeneration or Waste Heat Recovery	100	16
Energy Storage	61	2
Industrial/Commercial Energy Systems	66	24
Lighting	50	12
Recycling or Resource Recovery	115	19
Transportation	37	58
ENERGY CONSERVATION (NON-BUILDINGS)	828	165
Energy General	533	174
Energy Management	96	34
GENERAL ENERGY	629	208
TOTAL	6,699	786

Attachment 5



NATAS TECHNICAL ASSISTANCE
How Each Technical Ass't $ is Spent



NATAS BUSINESS ASSISTANCE
How Each Business Ass't $ is Spent

Attachment 6

Code: INFO = General Information and referrals
TECH = Engineering/Scientific Technical Assistance
COMM = Commercialization Technical Assistance

Geographic Distribution of NATAS Users
(May 1, 1984 -- December 31, 1985)

		CUMULATIVE TO DATE				First Quarter FY86			
Rg	STATE	INFO.	TECH.	COMM.	TOTAL	INFO.	TECH.	COMM.	TOTAL
	Foreign	23	1	0	24	7	0	0	7
1	Connecticut	78	110	5	193	7	33	0	40
1	Massachusetts	140	147	22	309	9	14	3	26
1	Maine	44	63	8	115	4	15	1	20
1	New Hampshire	39	54	3	96	1	6	0	7
1	Rhode Island	15	31	2	48	0	4	0	4
1	Vermont	38	55	6	99	5	2	0	7
	REGION 1	354	460	46	860	26	74	4	104
2	New Jersey	109	132	9	250	10	15	0	25
2	New York	360	471	33	864	40	64	10	114
2	Puerto Rico	2	4	3	9	0	0	0	0
2	Virgin Islands	5	9	0	14	0	1	0	1
	REGION 2	476	616	45	1137	50	80	10	140
3	Dist. of Columbia	94	89	8	191	4	11	2	17
3	Delaware	24	32	3	59	1	8	1	10
3	Maryland	93	142	19	254	6	19	2	27
3	Pennsylvania	315	244	21	580	12	19	1	32
3	Virginia	178	214	27	419	12	42	10	64
3	West Virginia	23	31	1	55	2	7	1	10
	REGION 3	727	752	79	1558	37	106	17	160
4	Alabama	46	58	7	111	1	10	0	11
4	Florida	93	155	25	273	9	17	0	26
4	Georgia	89	127	10	226	4	20	2	26
4	Kentucky	50	58	7	115	2	6	1	9
4	Mississippi	9	16	0	25	1	4	0	5
4	North Carolina	154	110	31	295	11	10	20	41
4	South Carolina	41	90	7	148	4	8	0	12
4	Tennessee	45	59	11	115	4	6	5	15
	REGION 4	527	673	98	1298	36	81	28	145
5	Illinois	213	197	16	426	11	12	1	24
5	Indiana	68	126	8	202	4	20	1	25
5	Michigan	306	387	50	843	254	144	7	405
5	Minnesota	395	142	17	554	15	20	2	37
5	Ohio	133	160	28	321	10	24	4	38
5	Wisconsin	208	149	12	369	11	17	0	28
	REGION 5	1423	1161	131	2715	305	237	15	557

Geographic Distribution of NATAS Users

Rg	STATE	CUMULATIVE TO DATE INFO.	TECH.	COMM.	TOTAL	CURRENT QUARTER INFO.	TECH.	COMM.	TOTAL
6	Arkansas	27	75	12	114	2	17	4	23
6	Louisiana	40	64	8	117	2	4	1	7
6	New Mexico	99	76	20	195	3	18	1	22
6	Oklahoma	42	90	13	145	2	20	1	23
6	Texas	91	194	21	306	5	20	3	28
	REGION 6	299	504	74	877	14	79	10	103
7	Iowa	54	72	11	137	8	8	0	16
7	Kansas	51	87	24	162	3	12	3	18
7	Missouri	115	163	36	314	8	20	2	30
7	Nebraska	45	104	7	156	5	13	1	19
	REGION 7	265	426	78	769	24	53	6	83
8	Colorado	115	242	40	397	13	43	4	60
8	Idaho	26	79	9	114	3	10	2	15
8	Montana	159	471	25	650	7	60	6	73
8	North Dakota	29	56	5	90	1	5	0	6
8	South Dakota	10	31	8	49	1	1	2	4
8	Utah	38	79	25	142	4	14	16	34
8	Wyoming	14	34	4	52	0	2	0	2
	REGION 8	386	992	116	1494	29	135	30	194
9	Arizona	34	67	21	122	3	9	2	14
9	California	302	687	93	1082	32	126	10	168
9	Hawaii	7	15	25	47	1	7	22	30
9	Nevada	22	49	6	77	3	5	2	10
9	Guam	0	1	0	1	0	0	0	0
9	North Mariana Is.	1	11	0	12	0	2	0	2
9	Am. Samoa	1	13	0	14	0	1	0	1
9	Trust Terr.	0	3	0	3	0	0	0	0
	REGION 9	367	846	145	1358	39	150	36	225
10	Alaska	39	72	1	112	2	12	0	14
10	Oregon	62	100	6	168	3	12	0	15
10	Washington	149	217	29	395	12	31	5	48
	REGION 10	250	389	36	675	17	55	5	77
***		5097	6820	848	12765	584	1050	161	1795

GRI
gas research institute

1331 Pennsylvania Avenue, N.W.
Suite 730 North
Washington, D.C. 20004-1703
202/662-8935

DAVID O. WEBB
Senior Vice President,
Policy and Regulatory Affairs

March 7, 1986

RECEIVED
MAR 10 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development and Applications
Committee on Science and Technology
U.S. House of Representatives
2269 Rayburn House Office Building
Washington, DC 20515

Dear Mr. ~~Chairman~~ Don:

Attached is a copy of a written statement the Gas Research Institute (GRI) would like to have submitted for the record in relation to your subcommittee's hearing of March 6 on conservation issues within the Department of Energy. I would appreciate your including this statement as a part of the record.

The GRI budget recommendation has carefully considered the restraints necessary to reduce the large federal deficits and has limited funding requests to those programmatic areas where GRI is already providing significant resources for near-term research. Therefore, the FY 1987 budget recommendation of $25 million in gas-related research projects in DOE's conservation program will provide the resources necessary for a truly cost-effective joint program with the gas industry. This recommended DOE research program will not only continue long-term core technology projects, but will also effectively leverage taxpayer funds since GRI is budgeting $60 million in 1987 for near-term research in these same technologies.

Specifically, GRI is recommending DOE fund research efforts in gas heat pumps at a level of $10 million with the gas industry providing $14.4 million for a joint effort necessary to develop a cost-competitive heat pump by the early 1990's for the over 40 million homes that now use gas. Also, GRI is recommending a DOE budget of $10 million for industrial cogeneration and processes research to supplement the more than $15 million GRI budget in 1987 for research in these same technologies.

The national goal of more efficient use of our domestic resources can be achieved through effective federal/industry research programs. However, the federal government must continue to fund long-term core technology research while the gas industry continues to increase its funding and commitment to the near-term research leading to commercialization. The GRI budget recommendation provides for this core technology.

If you have any questions about the GRI budget recommendations or testimony, I will be glad to respond to them. Thank you for your consideration of this request.

Sincerely,

David O. Webb

David O. Webb

Attachment

cc: F. James Sensenbrenner, Jr.
William T. Harvey

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STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
MARCH 7, 1986

I appreciate the opportunity to submit testimony which discusses the Gas Research Institute's (GRI) views and FY 1987 budget recommendations for gas-related research in the Department of Energy's (DOE) conservation programs. Within the gas industry's overall recommendation of $25 million for long-term gas research in conservation, GRI is recommending a core program of $10 million for heat pumps, $5 million for waste energy reduction, $5 million for industrial cogeneration, $3 million for indoor air and building environment systems, and $2 million for desiccant systems. Central to this $25 million recommendation for a DOE program in long-term gas-related research is the fact that GRI is planning to fund $60.9 million in 1987 for near-term research in the same program areas.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and develops financing for a cooperative research and development (R&D) program for the mutual benefit of the gas industry and its present and future customers. The R&D program is implemented through contracts with research organizations, engineering and other professional service firms, universities, energy companies, and manufacturers. Funding for the GRI R&D program is provided primarily through regulated sales of natural gas. An R&D funding unit, approved annually by the FERC, is incorporated into the cost of gas of GRI's 32 interstate pipeline company members. GRI members, subject to appropriate state approvals, also apply a similar charge to their intrastate and direct industrial sales. Even though GRI is not a government contractor and does not accept federal funds, GRI cofunds and coordinates many of its research programs with DOE. Therefore, the actions of Congress on the proposed FY 1986 budget deferrals and the FY 1987 DOE budget have a direct impact on the gas industry's research program.

NEED FOR REVISED FEDERAL ENERGY R&D PRIORITIES

Energy conservation continues to play an important role in improving the nation's energy and economic efficiency. While efficiency continues to improve, total U.S. energy consumption rose during 1984 for the first time in five years. This increase (to 74 quads) represents a rise of about 4 percent from 1983 levels. It is attributed, in part, to the nation's increasing economic growth, which expanded by 6.8 percent in 1984. The rise in total energy consumption serves as a reminder that conservation must continue to play a prominent role in national energy policy to ensure the nation's long-term energy security and economic well-being.

Many important opportunities remain to cost effectively reduce future energy demand through innovation and through the introduction and commercial application of advanced, highly efficient energy-related technologies. By using advanced technology, the U.S. can probably economically double the efficiency gains made in the past decade by 2010 even if current energy prices remain stable or experience a moderate decline.

To quote from the administration's FY 1987 budget request, "The mission of the Conservation Research and Development Program is to encourage the full development of energy conservation's potential and to provide a robust array of technology options to strengthen the technology base on which industry can draw in developing future new products and processes for the commercial market."

It is naive to believe that DOE can hope to accomplish its conservation R&D goals with funding that is less than 1 percent of its total R&D budget and with new budget authority at only 20 percent of last year's appropriation for conservation programs. This budget does not represent sound national energy policy.

DOE FY 1987 ENERGY R&D FUNDING PRIORITIES

While a balanced energy policy would establish a proportionate relationship between R&D funding and the actual potential to use U.S. energy resources efficiently, DOE has proposed an unbalanced budget again in FY 1987. To illustrate this imbalance, the proposed DOE FY 1987 budget request for the Strategic Defense Initiative (SDI) program is $604 million--about 17 times the new budget authority the conservation program. If federal energy R&D funding continues this downward spiral, in a few years the nation will once again find itself faced with rapidly rising levels of oil imports because it has not established the necessary technology base to fully develop its conservation technologies and to use them efficiently.

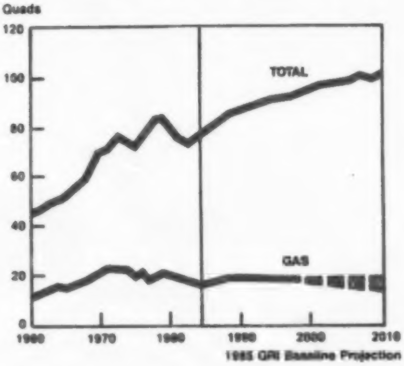
DOE must provide a stable funding base for long-term, high-risk gas-related research while the regulated gas industry is increasing its near-term research funding. In contrast to the need for a balanced research policy, the proposed FY 1987 DOE Conservation Research Program is $34.4 million--down approximately 80 percent from the FY 1986 appropriated level of $170.9 million. In summary, the administration's proposed FY 1987 conservation research budget is not consistent with a rational energy policy and certainly does not provide stable funding for a core program of long-term gas research.

National energy policy as modified by Congress has stressed and encouraged development of ample supplies of domestic energy resources and the more efficient use of energy to reduce the dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for critical conservation research programs in DOE. Maintaining adequate program funding is necessary if the U.S. is to successfully develop the full potential of its vast domestic energy resources.

GAS SUPPLY OUTLOOK

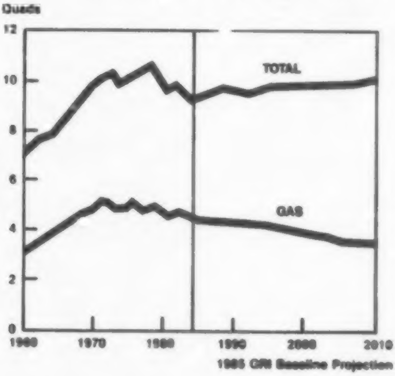
As background to evaluate the national priority of funding a federal research program in the more efficient use of gas, it is important to note the projected trends for energy supply and demand. The 1985 GRI Baseline Projection of U.S. Energy Supply and Demand indicates that natural gas will continue to play a major role in a highly competitive energy mix well into the next century. Continuing growth in total primary energy consumption is projected to increase from 77.8 quads in 1984 to 102 quads in 2010 at a rate of 1.1 percent per year. Primary natural gas consumption is expected to increase modestly from 17.9 quads in 1984 to 18.7 quads in the year 2000. Thereafter, if advanced technologies for cost-competitive production of gas from low-permeability formations and other cost-competitive unconventional resources become available, gas can continue to maintain this level of consumption through 2010.

PRIMARY ENERGY CONSUMPTION



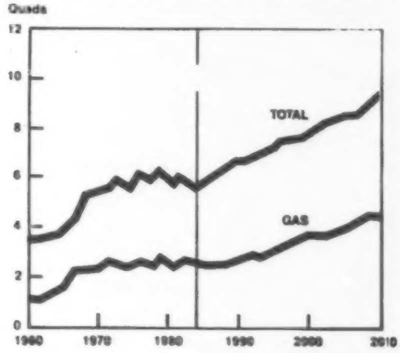
Residential gas consumption is projected to gradually decline from 4.5 quads in 1984 to 3.6 quads in 2010, although the number of gas-heated housing units is projected to increase from 44.6 million in 1984 to 57.0 million in 2010. This outlook is consistent with long-term historical trends and results from equipment efficiency improvements, increased renewable energy consumption to serve a portion of the loads, and improvements in housing shell thermal integrity.

RESIDENTIAL ENERGY CONSUMPTION



Commercial gas consumption is projected to increase over the entire projection from 2.4 quads in 1984 to 4.5 quads by 2010. Commercial gas consumption is expected to be significantly increased by the widespread application of gas-fired cogeneration. The projection includes 1.0 quad of gas-fired commercial cogeneration in 2000 and 1.7 quads in 2010.

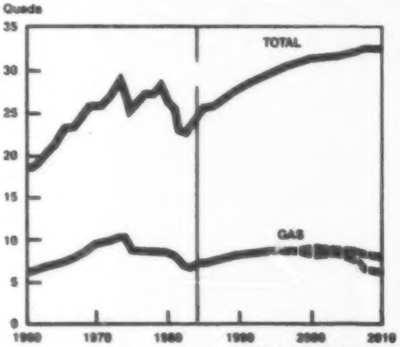
COMMERCIAL ENERGY CONSUMPTION



1985 GRI Baseline Projection

Industrial gas consumption is projected to increase gradually from 7.4 quads in 1984, reaching 8.2 quads in 1990 and 8.4 quads by 2000. A substantial portion of the projected increase in industrial gas consumption also is the result of rapid growth in gas-fired cogeneration. Gas consumption for industrial cogeneration grows from 0.3 quad in 1984 to 1.2 quads in 2000.

INDUSTRIAL ENERGY CONSUMPTION



1985 GRI Baseline Projection

In every end-use sector, the ability of natural gas to be used most efficiently will depend upon maintenance of a strong and evolving stock of gas utilization technologies.

Establishing the technology base and developing the processes and equipment to use gas most efficiently in the residential/commercial and industrial sectors requires a lead time of 10 to 15 years. The current gas deliverability surplus and softening of world oil prices gives us the opportunity to pursue this critical technology development in an orderly fashion rather than responding to a crisis situation. While we have the time, we must seize this opportunity to strengthen our domestic energy potential. To do so, GRI is recommending $25 million for a core program of gas-related research in the DOE conservation budget. Thirteen million dollars is for research in DOE's Building and Community Systems Program, and $12 million is for industrial utilization research. This long-term DOE core program will be supplemented by the $60.9 million GRI budget in 1987 which focuses on near-term efficient utilization research.

GRI'S RECOMMENDED FY 1986 DOE LONG-TERM
GAS-RELATED CONSERVATION RESEARCH FUNDING
($ Millions)

Gas Heat Pump and Prime Mover	$10.0
Industrial Processes	10.0
Building Systems/Indoor Air Quality	3.0
Desiccant Cooling Systems	2.0
TOTAL	$25.0

In the past three years, Congress has recognized the need for a long-term DOE program in the efficient utilization of gas and has appropriated approximately $25 million each year for this research. The gas industry is seeking a continuation of this trend in FY 1987.

GAS RESEARCH INSTITUTE'S 1987 BUDGET

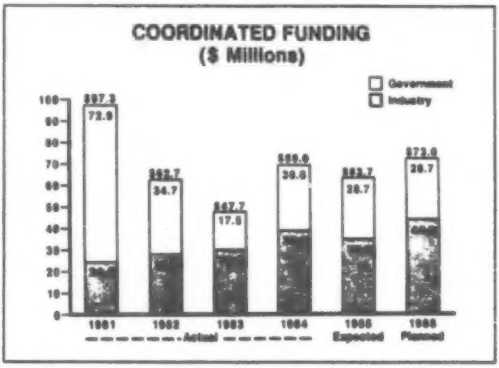
In contrast to the DOE policy of reduced funding for long-term gas research in efficient utilization, the gas industry has responded rapidly and impressively to federal R&D policy by funding more of its own near-term research. GRI will propose to its Board of Directors in April a $175 million 1987 budget which includes $60 million for research on the efficient utilization of gas. The efficient utilization programs include $19 million targeted for industrial applications and $41 million directed at residential/commercial energy systems. GRI's 1987 obligations budget will be submitted to the FERC in June 1986.

End-use research will continue to receive the greatest emphasis in GRI's 1986 program (55 percent). This program includes work in residential/commercial energy systems, industrial utilization, and cogeneration, and concentrates on near-term and mid-term technologies.

1987 PROGRAM BALANCE
PERCENT OF TOTAL R&D BUDGET

	FROM 1986-1990 FIVE-YEAR PLAN		PRELIMINARY PLANNING BUDGET
	1986	1987	1987
SUPPLY OPTIONS	32.9%	35.0%	28.8%
END-USE	50.6	49.0	55.1
OPERATIONS	11.2	11.2	12.3
CROSSCUTTING	5.3	4.8	3.7

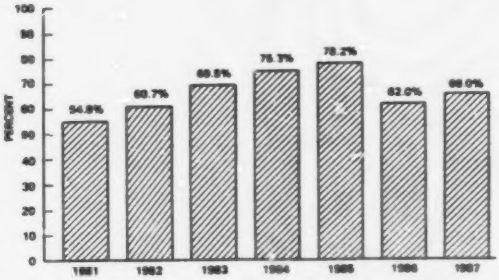
GRI policy continues to emphasize maximizing the level of the funded R&D program through acquisition of coordinated funding from both government and industry sources. Although government funding for gas-related R&D continues to be severely limited, GRI has maintained a number of important coordinated funding agreements with various government agencies. In 1986 GRI expects to supplement the total R&D program with $28.7 million in government-coordinated funding. Of this, approximately $7 million is for programs funded under the DOE conservation budget.



GRI policy also continues to require manufacturer or producer involvement in any effort that proceeds beyond the proof-of-concept stage. This involvement usually includes some form of coordinated funding. Such agreements serve both to supplement limited GRI budgets and to verify the commitment of the manufacturer or producer to carry the technology to commercial application. In 1986, through various funding arrangements, GRI anticipates a total of $44.3 million in coordinated funding from industry.

As the level of federal funding and support has declined since 1981, essential near-term gas research was no longer funded by DOE. GRI responded to this by cancelling or deferring some of its own projects with a longer-term payback and concentrating its limited resources on projects with a more immediate return to the industry and ratepayers.

NEAR-TERM BUDGET
Percent of Total R&D Obligations Budget



The natural gas industry has assumed responsibility for funding the near-term efficient utilization research and development by increasing its budget for those research activities over the past four years to $60 million in 1987. The administration should enter into a partnership with the gas industry by carrying out its responsibility of continuing the critical long-term, high-risk research at a FY 1987 funding level of $25 million.

CONSERVATION: PROPOSED GRI 1987 FUNDING
($ Millions)

Indoor Air	$ 2.10
Building Systems	1.55
Residential & Commercial Heating & Cooling Systems	7.40
Heat Pumps	14.45
Residential & Commercial Appliances	5.50
Cogeneration Systems	7.60
Industrial Energy Systems	6.10
Advanced Heat Transfer Systems	2.30
Burner System Development	3.65
Industrial Processes	7.80
Industrial Materials & Components	2.45
TOTAL	$60.90

RECOMMENDED DOE FY 1987 LONG-TERM GAS-RELATED RESEARCH PROGRAM IN CONSERVATION
Discussed below are several important long-term programs in efficient utilization gas research that are consistent with a balanced energy policy, have been supported previously by this Committee, and require continued federal funding.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Gas Heat Pumps and Prime Movers	$4.2M	$10.0M

GRI and DOE are currently in the process of negotiating a formal joint research program in the development of one of the most promising conservation technologies--gas heat pumps. The gas heat pump not only offers increased efficiency over existing gas-fired space conditioning equipment but also can provide heating and cooling in a single unit. Broad market acceptance of commercial as well as residential heat pumps could also contribute to load leveling and reduction in peak demand for some electric utilities thereby reducing operating costs.

Gas currently provides winter heating comfort for more than 40 million families in the United States. In the approximately 4 million commercial buildings, over 55 percent have natural gas hookups, and 50 percent use gas for space heating. Therefore, the successful development of a gas heat pump for the residential/commercial markets could be widely applied throughout the nation.

GRI has been participating with DOE over the past three years in a cooperative research program. GRI has concentrated on the more near-term aspects of the research, and DOE has focused on the longer-term advanced component and engine research necessary to develop a cost-competitive gas heat pump system. The proposed joint DOE/GRI program would include two broad categories of gas heat pump research: mechanical heat pumps and absorption heat pumps. Mechanical systems use gas engines instead of electric motors to drive a system in which a refrigerant vapor is alternately compressed and expanded in a continuous cycle. Absorption systems use the heat from gas combustion to sustain a fluid separation cycle employing evaporation and absorption.

The GRI strategy calls for development of a first-generation heat pump for market introduction by 1990 and an advanced heat pump using new engine technology for introduction in the mid-1990s. Reaching these goals in a timely manner will require an expanded and cooperative DOE/GRI research program. Although there are many difficult technical issues that must be addressed in each of these concepts, a common barrier is the first cost. The unit cost must provide a payback within five years, and the equipment must have a service life of approximately 40,000 hours. DOE and GRI must work together on a technical basis to define a national R&D program to advance this technology.

The four main elements of the proposed joint DOE/GRI comprehensive gas heat pump program are:

1. System Development concentrating on R&D for an entire heat pump system or major component.

2. New Concepts Evaluation of promising technical approaches at a very early stage of development.

3. Supporting Research consisting of fundamental research in basic processes, phenomena, and materials; generic component development; and cross-cutting research on new analytical tools.

4. System Analysis focusing on studies to set generic R&D goals and identify specific components and subsystems improvements.

GRI is looking at a funding profile to support the research program outlined in the following table.

ANNUAL HEAT PUMP BUDGET REQUIREMENTS SUMMARY
($ Millions)

		DOE	GRI	Total
SYSTEMS DEVELOPMENT		$ 5.5	$10.2	$15.7
Absorption	$6.1			
Stirling	5.6			
I.C. Engine	4.0			
NEW CONCEPTS EVALUATION		0.7	0.5	1.2
SUPPORTING RESEARCH		3.0	2.9	5.9
Absorption	$2.0			
Stirling	2.4			
I.C. Engine	1.0			
Other	0.5			
SYSTEMS ANALYSIS		0.8	0.8	1.6
TOTAL ANNUAL BUDGET		$10.0	$14.4	$24.4

Multiple technological options are needed for the residential market to solve the critical problems of unattended performance, first cost, and reliability. The technology concepts being pursued include double-effect and dual-cycle absorption heat pumps and heat pumps driven by reciprocating internal-combustion engines, rotary internal-combustion engines, and free-piston Stirling engines.

Development of small internal-combustion engines for use in heat pumps would have other applications such as cogeneration. Initial research has shown that the needed improvements in engine life, maintenance requirements, and controls are definitely achievable. Several attractive long-term technologies, specifically free-piston Stirling engines and free-piston internal-combustion engines, show potential. These should be developed as an element of the gas heat pump program. Research needs to be conducted in the areas of dynamic component matching, improved high-temperature materials, ceramic development and application, seal technologies, heat exchangers, use of microprocessor electronic engine controls, and high-temperature lubricants.

A viable U.S. gas heat pump and prime mover program requires a joint federal/gas industry effort with DOE funding $10 million and GRI funding $13-14 million per year.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Desiccant Cooling/Refrigeration Systems	$0.0M	$2.0M

Today, the cooling needs of most small commercial buildings are being met with electric vapor compression air conditioners and heat pumps. However, in areas of the country that experience high humidity and in commercial buildings that have high internal humidity loads, the use of these systems to handle both the moisture (latent) and cooling (sensible) loads is often inefficient in terms of energy and equipment utilization. An alternate and more efficient approach is the use of an integrated gas-regenerated desiccant dehumidifier in conjunction with a smaller-capacity electric vapor compression air conditioner. Warm air from a gas burner is used to dry or regenerate the desiccant material which absorbs or removes moisture and thereby handles the latent cooling load. An electric air conditioner meets the sensible load.

GRI is field testing the concept of an integrated gas desiccant/electric air conditioner in several supermarkets. A supermarket is a good application for such a system since the operation of freezer and cooler cases reduces the sensible load and leaves approximately one-half of the air conditioning load to provide dehumidification. Current systems result in oversized air conditioners which are operated at high load factors and low evaporative coil temperatures. The result is poor efficiency and high operating costs.

While GRI concentrates on these near-term integrated gas-electric systems, DOE should initiate research on more advanced gas desiccant systems. The research should have as its goal a total desiccant cooling system (no electric cooling components) in sizes from 10 to 20 tons. Key technology improvements are needed in reducing the size and cost of the desiccant wheel and heat exchanger components. Funding of $2 million is required in FY 1986.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Building Systems/Indoor Air Quality	$1.9M	$3.0M

DOE should continue its research efforts to develop inexpensive passive monitors for measuring indoor air quality at a relatively low cost. Efforts should focus on infiltration, ventilation, and air movement in buildings. The impact of reduced air exchange rates on indoor air quality is not well understood, and investigations are required to develop an accurate and reliable data base. The DOE funding of $3 million will be supplemented by a GRI budget of $3.65 million in 1987.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Industrial Cogeneration	$4.7M	$ 5.0M

Gas-fired cogeneration can supply both electrical and thermal energy service in a highly efficient manner. The environmental and strategic benefits of gas-fired cogeneration are also significant, since efficient use of clean-burning gas from domestic sources decreases total emissions and helps reduce unacceptable dependencies on imported petroleum fuel supplies.

Energy conversion efficiencies in the 30 percent range, typical of equipment currently dominant in industrial and electric power-producing installations, are no longer economically competitive. Cogeneration of electricity or shaft horsepower and useful heat at overall efficiencies of 70 to 80 percent is possible through a coordinated federal/industry research program. New approaches that meet the combined thermal, shaft horsepower, and electrical requirements of an industrial facility are needed.

The technical potential for cogeneration has been estimated to be as much as 200,000 megawatts in a recent study by the Office of Technology Assessment. Much of this potential is in the industrial sector which continues to be the largest energy-consuming sector of the U.S. economy--accounting for approximately 38 percent of total U.S. gas consumption in 1984. Despite the significance of natural gas use in the industrial sector, the potential for cogeneration has only begun to be realized recently. The major problem is to develop and build advanced systems with improved operating efficiencies and ease of maintenance. The DOE research should concentrate on developing advanced materials, components, and compressors to handle higher temperatures necessary to boost efficiencies.

GRI's research efforts are focused on the more near-term problems of demonstrating cost-effective packaged cogeneration systems for the commercial and light-industrial markets. GRI's industrial sector R&D program, with substantial technical and financial support from industrial equipment manufacturers and end-users, is structured to overcome the present constraints facing the industrial gas consumer. GRI is currently developing packaged cogeneration systems in sizes ranging from 50- to 1000-kilowatt electrical output. These units will have greater than 75 percent overall efficiencies at installed costs of less than $1000 per kilowatt for application in commercial buildings and multifamily dwellings. Last July an experimental packaged 500-kilowatt cogeneration system began a one-year field test at a hospital in Houston, Texas. This packaged system, designed and built under a cost-shared GRI contract by Martin Cogeneration Systems, is just one project in GRI's effort to target cogeneration packages at major groups of applications that share similar, fairly predictable energy requirements. GRI's proposed 1987 budget contains $7.6 million for these near-term cogeneration activities.

The longer-term program DOE needs to fund is to establish and conduct a parallel research program with emphasis on developing advanced materials and advanced heat transfer and thermodynamic and microprocessor concepts. These components and concepts must then be integrated into prototype units to allow industry to evaluate the effectiveness of the systems. This R&D will improve the cost-effectiveness, efficiency, reliability, and flexibility of cogeneration systems. The result is increased cost savings and expanded potential applications for gas-fired cogeneration systems. Improved components from this DOE-sponsored research can be integrated into both first- and second-generation packaged systems. To this end, it is recommended that DOE consider development programs in the following areas:

- o industrial-size induction generators for use with natural gas prime movers,
- o less expensive waste heat boilers,
- o improved natural gas compression equipment for combustion turbines,
- o standardized grid interconnect systems for prepackaged industrial-scale systems, and
- o improved heat rate combustion turbines and other advanced prime movers in the 2- to 10-megawatt class.

DOE funding of $5 million in FY 1987 is recommended.

SUMMARY

A viable, consistent DOE core program of long-term gas research in efficient utilization is essential as one central element of a balanced federal energy policy. GRI recommends a DOE FY 1987 budget for long-term gas-related research in its Conservation program of $25 million consisting of $10 million for gas heat pumps and $5 million for industrial cogeneration, $5 million for waste energy reduction, $3 million for indoor air and building environment systems, and $2 million for desiccant systems.

STATEMENT OF
HERBERT M. BOYD
MANAGER-FORECAST & STRATEGIC PLANNING
ALABAMA POWER COMPANY

Submitted for the Record

to:

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

Hearing Entitled:

"Department of Energy's FY 1987

Authorization for Conservation and Renewable Energy"

February 27, 1986

I appreciate you giving us the opportunity to present a utility view on research expenditures required between now and the year 2000. The Southern Company and Alabama Power Company, in particular, are concerned about the prospects of having new technology available to meet its generation requirements in the years 1995 - 2000.

We have had a number of national leaders such as John F. Kennedy who fostered the idea of the new frontier and President Reagan, who is currently fostering the idea of opening that frontier. Each of these presidents appears to have had a vision of what they believe the future holds for this industry. As I understand both of their approaches, energy will be required in great abundance to make these two visions possible. The economy and their visions will only move forward in response to energy availability.

We in the utility industry know that the social aspects of our society have created a concern for the environment in which we operate and live. This concern has created untold amounts of regulation which place pressure upon the energy supplying community. The utility industry and Alabama Power Company, in particular, are concerned that if sufficient research is not performed to develop new technologies then the old technologies will have to be utilized to meet the increasing energy needs of our society. This being the case, the adaptation of existing technology to meet the increasing needs might not be sufficient and the cost to society might be prohibitive.

The Southern Company system is continuing to plan for generation to meet its customer requirements. As a point of reference the embedded cost of capacity in 1973 was $117 per KW. The difference in these costs represent the change in cost due to technology as well as inflation and environmental requirements. The significant fact is that we are projecting that the cost of installed generation by the year 1991 will be $1708 per KW. It is clear from these numbers that every effort should be made to identify any technology which could impact these costs in a positive way.

We can state that the current technology being utilized to produce electric energy is not obsolete; it is, however, mature and the dollars required to increase the efficiency of that technology in response to required environment changes and societal needs will be tremendous. Therefore, with the pressure of regulation and competition it is time that we as a nation attempt to sustain a program that has pushed the development of new technology which are not currently available or ready for application. We need to take a sustained approach to solving the technological problems associated with emerging technology and commit to a long range program to identify energy producing technologies.

We can state that there is no "clear" winner in the set of new technology currently being investigated. Therefore, we as a nation can take three possible approaches to doing basic research on new energy producing technologies. We can make no expenditures on basic research and in the period 1995 - 2000, when most utilities will have to make large additions to meet this country's energy requirements, we will be forced to install technology that was developed in the 1960's & 1970's. This clearly would not be an efficient alternative. We can make some expenditures in basic R & D and maintain our current level of technology. This will allow us to install 1980 technology in the year 2000. Still not an acceptable alternative but one that would at least be better than making no expenditures. The best alternative, however, is to make expenditures at least at a level which would maintain the critical mass of research. This is the level of expenditure required to move technology forward so that when the period 1995 - 2000 does arrive we can meet the full requirements of our society.

Photovoltaics, the direct conversion of sunlight to electricity, is one of the promising options to help meet the electrical demand of the country in the 1990's and beyond. The government has an important role to play in the development of the photovoltaic technology because energy is of national and world importance. Any new technology like photovoltaics takes time to develop. As a high risk technology, it demands a continual commitment on the part of both the government and private sector to ensure steady progress toward a favorable outcome. As a high technology with associated high risks, photovoltaics also demands a long term commitment to nurture its development.

The past and present government program in photovoltaics has resulted in technological progress. Increasing the risks of technology development has also been shared between the public and private sectors through the use of federal/industry partnerships. However, the government's support has tended to fluctuate wildly, simply following the rapid changes in the price of oil. This results in disrupting the steady progress in developing the research base and forces researchers and private sector planners to question the priorities of the Government's interests. In the meantime, our competitors' program from across the Pacific - Japan, under the sponsorship of the Ministry of International Trade and Development (MITI) - at the very least consists of a steadily increasing government support base with a strong interrelationship with their private companies. In turning to photovoltaics for power generation, America had a clear leadership position in technology development through the 1950's to the early 1980's. However, 1985 may prove to be a turning point, and 1986 should show Japan as a leader in a strong position to develop photovoltaic products for an export market. Surely, the U. S. Government is capable of better planning for a more effective use of public resources to meet the challenges of the 1990's in supplying the country's energy needs through a mix of energy resources.

The photovoltaic industry is still very small compared with other high technology industries. Revenues for 1985 are estimated to be only $150 million. Profitability is virtually non-existent. World economic forces have slowed the deployment of the technology. Further technical progress must be made in reducing the cost of photovoltaics to accelerate its growth. Industry alone cannot afford to support the research necessary to make this technical progress in a timely fashion, since its revenue base is so small. Continuing government help is mandatory to develop the scientific foundations upon which a large scale industry can grow.

You are wrestling with the problem of when do I make technology expenditures. I would like to give you just one R & D guideline, "When the existing technology requires tremendous expenditures in order to increase the output for the same dollar input and no technology is present that has the potential for producing large outputs for small input expenditures then large R & D dollars are required to develop new technology." This is where we are today.

The overall DOE photovoltaic research program has the right goals. Increasing the efficiency and increasing the utilization of the available light spectrum is a must if photovoltaics are to ever be competitive with current generation resources. It does, however, appear that a strategy assessment of the areas of priority should be made so that the R & D on photovoltaics could be focused in a direction to solve problems necessary to speed the commercialization and economics of the photovoltaic technology. As other technologies have proven, universities are an excellent resource for basic research. The universities in this country have made a large contribution to basic research and they will continue to do so in the future, however, universities can not be expected to make the contributions which will be required for commercialization. They can, however, help us in the area of performance and stability and they can generate new processes for fabricating devices which result from their basic research. This leaves a large area within the general field of R & D that must be carried out by those people which are attempting to commercialize and improve the economics of the technology. These two efforts must go hand in hand if we are to successfully complete our goals in the photovoltaic industry. The budget which DOE has described does not address the attending delays that will result from the budget reductions which have been identified. Therefore, it appears that no one is assessing the cost of the delays and the attendant risk that will result from those delays. This risk is that we will not have a photovoltaic technology ready when it is needed unless we move forward with an ambitious R & D program today.

The electric industry is willing to make application of proven technology to meet its customer requirements. Being regulated, utilities have traditionally been unable to spend the large amount of capital required to do basic research.

In order to increase flexibility, we are reviewing a wide range of potential sources of additional generating capability and load control techniques other than the traditional central station power plants. This efforts includes:

A. Solar Technology. We have promoted in several ways the development of new technology aimed at making solar resources more attractive as a source of electricity for the future at competitive prices. Our joint venture with Chronar Corporation for the development of a factory in Alabama to produce solar cells is one such project. In addition we are installing a 100

KW amorphous silicon generating plant which will be integrated into the electric grid at Varnons, Alabama. This plant is designed to aid in research concerning the use of photovoltaics.

B. Cogeneration Efforts. We have established a task force within the system companies to explore with customers those applications of cogeneration which make sense to the customer and which also are complimentary to our plans for meeting loads in the future. While the Southern electric system companies have no current avoided capacity costs as a result of the installation of cogeneration, we recognize that such resources may be valuable to meet our load requirements in the future.

C. Other Non-Traditional Resources. Our research and development organization, in addition to participating on various projects with EPRI, is continuously engaged in looking at development of other non-traditional resources for production of electricity such as the advance coal liquefaction project which the southern electric system has supported at Wilsonville, Alabama, and fuel cells powered by methane gas from coal beds.

We also expect to be able to control our loads more effectively in the future. Toward that end, we are exploring numerous means of promoting load management and conservation. One of our major current efforts is the promotion of the wise use of electricity for residential purposes through our Good Cents Homes Program. This program establishes voluntary standards to assure an energy efficient home design. Through application of these standards, our customers are encouraged to make wise use of electricity and at the same time reduce the overall cost of home heating and cooling.

In pursuing a strategy of flexibility, we have also been exploring the revitalization of generating plants in lieu of retirement of those plants. Normally, a steam electric generating plant is expected to remain in service for 30 to 40 years. If the life of these plants can be extended, an added degree of flexibility can be achieved to permit quicker response to upward changes in electric usage patterns. The advantages of revitalizing old units include making use of existing plant sites and providing resources in the short run at lower costs. The disadvantages include placing the reliability of the electric system at risk by reliance on units which are more than 40 years old; utilizing units with less efficient heat rates to serve loads; and using temporary, stop-gap measures while the cost of new generating plants continue to rise.

While we are pursuing all of these alternatives in order to maintain flexibility, it is apparent to us that in the long run, these resources will not completely replace the need for larger, central station power plants if we are to meet the demand for electricity in the late 1990's. In order to preserve the opportunity for developing these needed resources, impediments which currently exist to the development of such plants must be eased.

In closing, I would like to stress that it is society's responsibility to insure that adequate and efficient technologies are available in the future to meet its requirements. R & D dollars are required today if we want this to occur by the 1995 -

2000 timeframe. We, the electric utility industry, are looking to you to provide continued direction and incentive for the research that needs to be done. The best statement that you could make to the industry is that our society will continue to support the development of new energy producing technology.

Thank you very much.

DON FUQUA, Florida, Chairman

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Republican Staff Director

March 31, 1986

Hon. Don Fuqua, Chairman
EDA Subcommittee
2269 Rayburn House Office Building
Washington, DC 20515

Dear Don:

Last fall I requested the preparation of a report by the Congressional Research Service to put the Steel Initiatives into perspective. Lennard G. Kruger has prepared the attached document, which does an excellent job of categorizing out modernization technologies into state-of-the-art commercially available, new technologies ready for commercial demonstration, and unproven leap-frog technologies, which would radically improve steelmaking economics.

Mr. Kruger's report is readable and can be understood by the laymen. I hereby request that this report be included in the hearing record of your Subcommittee for FY 1987 DOE conservation budget so that it will be more readily available to those who wish to understand the significance of the Steel Initiative.

Sincerely,

Doug Walgren

DOUG WALGREN, Chairman
Subcommittee on Science,
Research and Technology

DW/Teg
Attachment

NEW TECHNOLOGY FOR THE U.S. STEEL INDUSTRY: A GREAT LEAP FORWARD?

Prepared at the request of the
House Subcommittee on Science, Research and Technology

Lennard G. Kruger
Analyst in Science and Technology
Science Policy Research Division
December 20, 1985

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I. INTRODUCTION

The ills of the domestic steel industry are well documented. According to the U.S. Bureau of Mines, in the past decade raw steel production in the United States has declined from about 150 million tons in 1973 to nearly 95 million tons in 1984. Steel industry employment has also plummeted, from 609,000 in 1974 to 273,000 in 1984. Meanwhile, imports of foreign steel continue to rise and indicate the lagging competitiveness of domescic steelmakers.

Many assessments of the domestic steel industry invoke technological factors both as a cause for the industry's current problems and as a hope for its future revitalization. For example, in hearings before the House Ways and Means Committee, F. Kenneth Iverson, Chief Executive Officer of Nucor Corp. (a leading operator of steel minimills) testified:

> There are two reasons why our primary steel industry has lost advantages it once had in the marketplace. One is that many of our steel plants are old and inefficient. In the last three decades, many of the major developments in steelmaking were made outside of the United States. Our larger steel companies have not quickly accepted technological advances and have adopted new techniques only when the economic evidence is overwhelming . . . . The second problem of our major steel producers is productivity. 1/

The potential of new technology was addressed by the Office of Technology Assessment (OTA) in its 1980 report, Technology and Steel Industry Competitiveness:

> The U.S. steel industry can be revitalized through increased investment in research and development (R & D) and the adoption

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1/ U.S. Congress. House. Committee on Ways and Means. Subcommittee on Trade. Problems of the U.S. Steel Industry. Hearings, 98th Cong., 2nd Sess., June 20, 1984. Washington, U.S. Govt. Print Off., 1985. p. 287.

> of new technology. For that to happen, however, steelmakers must increase their capital spending . . . 2/

Certainly, technology is a critical factor which has, does, and will help determine the competitiveness of the American steel industry. However, it is necessary that this statement be qualified in two ways. First, the development and implementation of innovative steelmaking technologies should not be viewed as the sole means to achieving industrial competitiveness. For example, the U.S. specialty steel industry, which is widely acknowledged to be the most technologically advanced in the world, is currently undergoing economic hardship due to high levels of imported stainless steel which have penetrated the domestic market. Many factors significantly affect steel industry competitiveness, including: trade laws, the strength of the dollar, labor costs, environmental regulation, raw materials cost and availability, tax laws, and others.

The second qualification is implied in the OTA statement above. The domestic industry does not lack in technological know-how; rather it lacks the capital to implement many new technologies. Richard Pitler, Vice President for Research at Allegheny-Ludlum steel stated the problem succinctly at a recent conference:

> To maintain an efficient steel industry in the United States, we must recognize the changes in technology that have been occurring and will occur in the industry, driven by forces over which the industry itself has little or no control. It should be recognized that the development of these technologies may be a necessary, but very insufficient condition for the survival of the industry. It will do no good to have the technologies developed if the industry does not have the capital to install them . . . . all the technological development in the world will not improve the competitiveness of the U.S. steel industry,

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2/ U.S. Congress. Office of Technology Assessment. Technology and Steel Industry Competitiveness. Washington, U.S. Govt. Print. Off., 1980. p. 3. (Hereafter cited as OTA, Technology and Steel Industry Competitiveness.)

nor keep it competitive unless capital is available to install new technologies. 3/

A discussion of steel industry prospects for generating the capital necessary to implement new technologies is beyond the scope of this report. Instead it will focus on the nature and status of new steelmaking technologies and the potential benefits they offer.

In this report, sixteen different steelmaking technologies were selected as specific examples on which to base a discussion of the nature, status and benefits of technology to the steel industry. The sixteen technologies and their definitions follow:

bottom stirring (bottom blowing) -- This is a modification of the Basic Oxygen Furnace (BOF). Traditionally, the BOF is operated by blowing oxygen on the top of the molten metal bath. In bottom stirring or bottom blowing (Q-BOP), oxygen or inert gas is blown through the bath's bottom. Blowing may also be done through both the top and bottom (known as combined blowing or K-BOP). Benefits of these processes include higher yields and better steel cleanliness.

continuous annealing -- Steel must be annealed or heat treated in a furnace to induce a level of hardness appropriate for the steel's intended application. A continuous annealer can do a job in 10 minutes which would take 5 to 10 days with conventional batch heat treatment. Continuously annealed steel also provides a higher quality, more uniform product.

continuous casting -- This is a process in which liquid steel is directly converted into slabs, blooms, or billets ready to be rolled and processed into finished products. Continuous casting replaces ingot casting, a much lengthier process where individual ingots of steel are cast in a mold, cooled, reheated, and rolled into slabs, blooms, or billets. Continuous casting offers significantly higher yields and lower energy consumption rates.

direct casting -- This process is intended to continuously cast steel into near net shapes so that the need for rolling is greatly reduced. Special attention is being focused on direct casting of thin sheet and strip.

direct current electric furnace -- This process improves the efficiency of an electric furnace by employing one graphite electrode using direct current rather than three graphite electrodes using alternating current. Reduced electrode consumption lowers the cost of operation.

3/ Pitler, R. K. Steel Industry Process Technology Trends. Materials and Society, v. 9, no. 2, 1985. p. 151.

direct reduction — In this process, iron ore is directly reduced into solid metallic sponge iron suitable for the steelmaking furnace. Traditionally, iron ore and coke are fed into a blast furnace to produce molten pig iron. With direct reduction, the blast furnace step is eliminated.

direct rolling -- In this continuous process, steel is cast and rolled without stopping. The steel is thus kept hot throughout each stage and the need for a reheating furnace is eliminated. Direct rolling is usually associated with ingot casting. A similar process, hot charging, is associated with continuous casting. In hot charging a small but greatly reduced amount or reheating is necessary between the slab casting and rolling cycles.

direct steelmaking -- A process in which iron ore is converted to steel in a single reactor. All reducing, melting, and refining functions would take place in one system. The process would replace the coke oven, blast furnace, and the basic oxygen (or electric) furnace. Currently, successful development of direct steelmaking faces profound technical obstacles.

eccentric bottom tapping — A refinement to the electric furnace which allows molten steel to be tapped through the bottom of the furnace to the ladle without any carryover of slag into the ladle. Cited advantages include reduced nitrogen pickup into the melt, reduced temperature loss, and a longer life for ladle refractories.

electrogalvanizing — Galvanizing is a process in which steel sheet is coated with zinc to enhance corrosion resistance. Traditionally, the steel is heated and "hot-dipped" into a molten zinc bath. By contrast, electrogalvanizing is an electroplating process done at near room temperature. The process imparts better corrosion resistance, better surface quality, a more uniform coating, and better formability and weldability.

energy optimizing furnace (EOF) -- This process uses coal and oxygen to melt scrap. The furnace can use charges ranging from 80 percent molten iron, 20 percent scrap to 100 percent scrap. Like the KS process, the EOF is an alternative to the electric arc furnace.

formcoking -- A process which converts low quality, inexpensive coal into high grade coke suitable for blast furnace ironmaking.

horizontal casting — Continuously casting horizontally instead of vertically translates into reduced space requirements and a much lower capital cost. Also an air tight seal between the tundish and the mold leads to quality improvements. Recently commercialized, the process must still demonstrate applicability to a wide range of products.

KR process — This process uses ordinary coal to produce pig iron. Solid iron ore is reduced in one chamber and then melted in another. The KR process would replace the coke oven and blast furnace. The need for high grade metallurgical coal is eliminated.

KS process -- An alternative to the electric furnace, this process uses coal and oxygen in the steelmaking vessel instead of electricity to melt scrap or iron sponge. A fuel cost savings of 40 percent over the electric furnace is claimed.

ladle metallurgy -- Also known as ladle refining or injection steelmaking, this is a process where steel is refined or alloyed in the ladle instead of in the melting furnace. Impurities, such as oxygen or sulfur, are removed by injecting powder (usually calcium) into the molten steel. Ladle metallurgy reduces the time required in the melting furnace, which increases productivity and yield, and decreases refractory consumption. Also quality is improved by reducing steel impurities and allowing closer analytical control of alloying elements.

While these sixteen technologies are commonly cited in assessments of steelmaking technology, the list is not all inclusive. Especially conspicuous in their absence are computer control and sensors, which can continuously monitor the composition, cleanliness and temperature of liquid iron and steel. While critically important, these technologies are more generic in nature and are an essential technological underpinning of many of the sixteen listed technologies. A discussion of any one of the listed technologies may include the sensor or computer controls that accompany it.

When considering the issue of technology and the steel industry, three factors must be accounted for in order to avoid an oversimplified view. First, in assessments of the steel industry, the term "new technology" is often employed as a catch-all label which can signify everything from the continuous caster (first commercialized in the early sixties) to direct steelmaking (which has yet to advance past the exploratory stage). Different stages of development and/or commercialization must be acknowledged.

Second, the contribution of a steelmaking technology to competitiveness does not hinge solely on its ability to cut production costs. For example, a technology could be beneficial despite increasing production costs if it produces a more desirable product which allows a company to expand its markets and sell more steel.

Third, the making of steel should not be viewed as a single process. It consists of a series of self-contained process stages. A new technology can often be associated with a specific stage of production.

This paper will discuss new steelmaking technologies within the context of these three criteria: benefits, stage of production, and stage of development. In particular, the technologies of the Federal Steel Initiative */ will be reviewed, and their implications for enhancing steel industry competitiveness will be examined.

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*/ A collaborative government-industry-university research program in which the national laboratories are utilized to develop next generation technologies for the steel industry.

II. HOW STEEL IS MADE

In order to understand steelmaking technologies it is necessary to understand the system to which these various technologies and processes are being applied. A detailed description of the steel production process is presented in the Appendix.

Briefly, the process begins with raw materials--either iron ore, coal and limestone--or steel scrap. Iron ore is pelletized or made into sinter cakes, limestone is crushed, and coal is made into coke in a coke oven. All three products are charged into a blast furnace which produces pig iron or "hot metal." Alternatively, iron ore may be directly reduced by natural gas or coal into iron pellets.

The next step is the steelmaking furnace; hot metal may be loaded into a basic oxygen furnace, iron pellets may be charged into a basic oxygen or electric furnace, or scrap may be added to an electric furnace. In all cases the result is molten steel, which is then either cast into ingots which are subsequently rolled into semifinished shapes, or continuously cast directly into a semifinished shape. Semifinished shapes include slabs, billets or blooms. Blooms are rolled into rails or structural shapes (such as construction beams). Billets are rolled into seamless pipe, wire rods, and bars. Slabs are rolled into flat rolled product (such as plate or sheet). Steel sheet usually undergoes finishing operations such as annealing (heat treating) for added strength, or galvanizing for added corrosion resistance.

An integrated steel mill is one which contains all the operations necessary to eventually convert iron ore and coal into a finished steel product. These include the pelletizing or sintering facility, coke oven, blast furnace, steelmaking furnace, caster, and the rolling and finishing facilities. A nonintegrated steel mill known as a minimill bypasses the primary end of the steelmaking process by using steel scrap in an electric furnace. Minimills generally produce wire, rods, bars and other small shapes. Another segment of the industry is the specialty steel industry, which manufactures alloy and stainless steels. In this paper, references to "the steel industry" primarily refer to integrated steelmakers unless otherwise indicated.

III. BENEFITS OF STEELMAKING TECHNOLOGIES

One of the principal benefits of implementing a new technology is a reduction of production costs. The following list presents operating savings which are attributed to some of the sixteen technologies listed earlier:

Technology	Estimated Operating savings
continuous casting	$40/ton of steel 4/
direct casting	$35/ton 5/
ladle metallurgy	$27/ton 6/
KR process	$25/ton 7/
energy optimizing furnace	$25/ton 8/
direct rolling	$12/ton 9/

4/ Brown, Warren. Bethlehem Steel to Modernize Two Plants. Washington Post, Dec. 10, 1983. p. 7.

5/ McManus, George. U.S. Steel and Bethlehem: A Partnership in Strip Casting. Iron Age, Aug. 6, 1984. p. 48.

6/ Fruehan, Richard. Ladle furnaces: Better output and lower costs. AMM, Sept. 23, 1985. p. 8A.

7/ Korf Engineering Gmbh. The KR Process for Production of Hot Metal and Reducing Gas on the Basis of Coal. Apr. 1984. p. 10.

8/ McManus, George. Korf is Back; This Time with a New Mill in Connecticut . Iron Age, May 17, 1985. p. 28.

9/ New 80-In. Mill Direct Rolls Quality Steel. Iron Age, Feb. 1, 1985. p. 45.

Technology	Operating savings
direct current electric furnace	$4.50/ton 10/
eccentric bottom tapping	$4/ton 11/
bottom stirring	$1 to 2/ton 12/

In its 1980 report, Technology and Steel Industry Competitiveness, OTA distinguishes between what it calls "radical" and "incremental" technologies:

> The term 'radical' is used to describe a process modification that eliminates or replaces one or more of the current steelmaking processes or creates an entirely novel option for ironmaking or steelmaking . . . . 'Incremental' technology developments include process modifications that improve efficiency, increase production, improve product quality or lower operating costs. 13/

The preceding list shows that technologies offering the largest potential savings tend to be radical; that is, they replace or eliminate major steps or stages of the steelmaking process. For example, continuous casting replaces ingot casting and primary rolling, direct casting eliminates hot rolling, and the KR process removes the need for the coke oven and blast furnace.

Smaller savings from the bottom of the list are due to incremental modifications of existing processes or equipment. For instance, eccentric bottom tapping and bottom stirring are cost saving modifications of the electric arc furnace and basic oxygen furnace, respectively.

10/ Sapino, Brenda. Nucor Says DC Arc Furnace Has Saved on Operating Costs. AMM, Oct. 22, 1985. p. 3.

11/ McManus, George. Electric Furnace Report: A Pipeline Full of Technology. Iron Age, Feb. 1, 1985. p. 32B5.

12/ McManus, George. The Answer is Blowing in the Furnace. Iron Age, Nov. 5, 1984. p. 24

13/ OTA, Technology and Steel Industry Competitiveness. p. 192.

It would be misleading to assume, however, that technology which is radical will automatically lead to reduced operating costs, thereby improving the competitiveness of the user of that technology. For example, direct reduction (DR) of iron is a radical process in which, typically, iron ore is directly reduced by natural gas to metallic iron pellets. It is a technologically proven short-cut around the coke oven-blast furnace route. Unfortunately, the high price of natural gas in the United States has made the DR process uneconomical for domestic ironmaking. Furthermore, the relatively low price of scrap currently makes the iron pellet product of DR uneconomical for many electric furnace steelmaking operations. Thus, raw materials prices and other economic forces can often wipe out apparent process efficiency advantages of a new technology.

Other technologies derive their attractiveness from factors apart from reducing operating costs. Continuous annealing and electrogalvanizing are being adopted because they produce a high quality product which will satisfy the needs of the automotive industry. For example, Bethlehem Steel spent $60 million and Inland Steel has spent $100 million to install continuous annealers which the companies hope will give them larger shares of the high strength auto sheet business. 14/ According to Ford Motor Company, use of high strength steel by the auto industry has gone from zero in 1975 to about 250 lbs per vehicle, and future use is projected to rise from 10 percent of dry weight to 15-20 percent by the end of the decade. 15/

Similar market needs have driven the widespread adoption of electrogalvanizing facilities. Electrogalvanizing produces a sheet product with a high

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14/ McManus, George. Continuous Annealing: Solving Old Problems with New Technology. Iron Age, July 4, 1983. p. MP-4.

15/ Ibid., p. MP-9.

quality surface finish and excellent corrosion resistance. In under five years, automobile companies intend to offer 10 year rust-through prevention guarantees, and because such a guarantee would require electrogalvanized steel in all exterior and exposed body panels, a 1.5 to 2 million ton increase in galvanized steelmaking capacity will be warranted. Accordingly, many integrated steelmakers including U.S. Steel, Inland and Bethlehem (in a joint venture), LTV, National, and Armco, have all begun constructing new electrogalvanizing lines. 16/

Capital cost and materials availability are yet more factors which drive the implementation of new steelmaking technologies. For example, the lower capital costs of horizontal continuous casting (as compared to conventional vertical casting) has been cited as one of the process' biggest advantages. Savings derive from the small size of the unit and the elimination of the need for the large structures and foundations associated with vertical continuous casters. At Armco, for instance, the compact design makes it possible to fit the caster into an existing melt shop. 17/

Formcoking has received attention due to a perceived inadequate coking capacity and the prospect of a future shortfall of metallurgical coke. The process produces blast furnace grade coke from low cost, low quality, and highly abundant steam coal. Concern over the availability of metallurgical coke also adds impetus to the development of the KR process, which uses lower grade coal and bypasses the blast furnace altogether.

16/ Wrigley, Al. Cars Soon to Up Galvanize Use 50 Percent. AMM, Dec. 21, 1984. p. 14.

17/ McManus, George. Horizontal Casting: A New Direction for Steel. Iron Age, Apr. 5, 1985. p. 30.

IV. STEEL TECHNOLOGY AND STAGE OF PRODUCTION

As mentioned earlier, the process of making steel is a series of discrete production stages. In general, integrated steelmaking can be broken down into five stages: raw materials preparation (this includes coke production and iron ore agglomeration), ironmaking, steelmaking (specifically processing iron or scrap into liquid steel), casting, and finishing. Of the sixteen steelmaking technologies featured in this report, most can be associated with specific production stages: 18/

1. Preparation of raw materials — formcoking;
2. Ironmaking -- direct reduction, KR process;
3. Steelmaking -- bottom blowing, direct current electric furnace, eccentric bottom tapping, energy optimizing furnace, KS process, ladle metallurgy;
4. Casting — continuous casting, horizontal casting, direct casting; and
5. Finishing -- continuous annealing, electrogalvanizing.

These five stages are predicated on the traditional integrated steelmaking route. However, evolving trends in the way that steel is made (alternate routes) could modify or eliminate some of the production stages needed, thereby reducing the attractiveness, relevance, or applicability of the technologies associated with these stages.

18/ It is more difficult to neatly place direct steelmaking or direct rolling into one specific category. Direct steelmaking combines the ironmaking and steelmaking stages, while direct rolling provides a continuous, energy-saving link between the casting and finishing operations.

For example, the further growth of electric furnaces or the widespread adoption of the KS process (which both rely on steel scrap or iron sponge, not liquid pig iron) would curtail the prominence of the raw materials preparation and ironmaking stages.

Even more striking in its ability to displace the steel production cycle is the recent practice of importing semifinished steel or purchasing semifinished slabs from other domestic mills. In 1983, U.S. Steel considered importing semifinished slabs from British Steel Corp. instead of spending the enormous sums necessary to modernize its Fairless Works. 19/ The plan fell through, but several integrated companies, including National Steel, Lukens Steel, and California Steel have imported semifinished steel during the last two years. According to the International Trade Commission (ITC), imports of semifinished steel have risen from 155,345 tons in 1980 to 1,515,734 tons in 1984. 20/

Obviously this option eliminates the need for the entire hot end of the production cycle--raw materials preparation, ironmaking, steelmaking, and casting are all bypassed, and the producer need only finish the solid steel into a final product. Thus, if importing semifinished steel were to become the wave of the future, the applicability of many of the technologies mentioned in this report would be sharply diminished. Naturally, many domestic steelmakers hope that implementing these technologies will prevent such a scenario from ever taking place.

Another trend in the steel industry is the increased emphasis on product quality. As steelmakers become more product and market oriented, the finishing

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19/ McManus, George. Steel Recasts Itself. Iron Age, Jan. 4, 1985. p. 88.

20/ Semi-Finished Steel Imports' Impact on Scrap is Analyzed. AMM, Aug. 22, 1985. p. 8.

end of the production cycle becomes more important. As discussed earlier, much money has been spent on electrogalvanizing and continuous annealing. Also the emphasis on quality and product has penetrated from the finishing end towards the hot end of the cycle. Ladle metallurgy processes, a part of the steelmaking stage, are becoming widespread. While contributing to process efficiency by refining liquid steel in the ladle instead of the steelmaking furnace, ladle metallurgy also offers significant quality gains by removing impurities and allowing better control of the steel's composition. Sensors coupled with computer controls are also being used throughout the production cycle to detect defects and automatically adjust processing parameters. An important goal is a higher quality, more saleable product.

V. STEEL TECHNOLOGY AND STAGE OF DEVELOPMENT

There is often confusion over the question: what constitutes a "new" technology? The steel technologies listed in this report are commonly considered "new." Yet, classifying each into a particular stage of development demonstrates a spectrum stretching from present day state-of-the-art to anticipated processes of the future.

Technologies can be grouped as either: widely commercialized or adopted; in preliminary stages of commercialization; or still in a research and development or exploratory stage.

WIDELY COMMERCIALIZED OR ADOPTED

In this category are acknowledged state-of-the-art, proven technologies which have gained widespread commercial use thoughout the world. These include: direct reduction, bottom blowing, eccentric bottom tapping, ladle metallurgy, continuous casting, direct rolling, continuous annealing, and electrogalvanizing. Domestic steelmakers have lagged behind their foreign competitors in adopting virtually all of these technologies. For further information on the efforts of the domestic steel industry to adopt new technologies, see the CRS report, "America's Steel Industry: Modernizing to Compete" by David J. Cantor (rept. no. 84-786 E).

PRELIMINARY STAGES OF COMMERCIALIZATION

This group includes those technologies which have been recently developed and are beginning to be marketed to steelmakers throughout the world. These include: horizontal casting, the direct current electric arc furnace, the energy optimizing furnace, the KS process, and the KR process.

In 1984 the first full scale horizontal caster in the United States was installed by Armco in its Baltimore plant. The machine was supplied by Technica Guss of West Germany. Chaparral Steel Co. has also installed a horizontal billet caster and is operating it on an experimental basis. Equipment suppliers report that the process is starting to be adopted worldwide. 21/ Meanwhile, Nucor Corp. is starting up a production scale direct current electric furnace at its Darlington, South Carolina, plant. If Nucor's experience shows that the furnace is practical for steelmaking on a production basis, continuing adoption of the process is expected. 22/

The energy optimizing furnace, a coal-based scrap melting process which produces liquid steel, is being installed in the new Connecticut Steel Corp. minimill being built in Wallingford, Connecticut. The process, recently introduced by the Korf Group, was first installed in a Brazilian steel plant to partially replace outmoded open hearth capacity. A second EOF system is expected to be operational at the same mill in December 1985. When on stream, this steel plant will be the first in the world to use the EOF process for its entire steelmaking operation. 23/

21/ McManus, George. Horizontal Casting: A New Direction for Steel. Iron Age, Apr. 5, 1985. p. 29-33.

22/ McManus, George. Electric Furnace Report: A Pipeline Full of Technology. Iron Age, Feb. 1, 1985. p. 32B2

23/ Brazil Firm Converting To EOF: Korf. AMM, Apr. 3, 1985. p. 4.

Like the EOF, the KS process can also use coal and oxygen to melt scrap into liquid steel. The Kloeckner Steel Corp. of West Germany developed the process, and in conjunction with CRA Ltd. of Australia, has run a KS process demonstration plant since November 1981. Klockner and CRA are marketing the process.

Perhaps the most promising new technology which is in a preliminary stage of commercialization is the KR process. This ironmaking process, which is owned by Korf Engineering of West Germany and Voest Alpine of Austria, relies on ordinary coal instead of metallurgical coke. Currently, the process is in place only at a 60,000 ton per year pilot plant in Kehl, West Germany. However, Korf has a contract to build a 300,000 ton per year facility for a South African company. 24/

American interest in the KR process is considerable. Several U.S. companies have tested domestic coal and iron ore at the German pilot plant and the results were favorable. The State of Minnesota, along with U.S. Steel and Korf Engineering, is seeking Department of Energy (DOE) funding to build a commercial scale demonstration plant in Minnesota. Total capital cost plus operating expenses for two years is estimated at $125-135 million. Minnesota has agreed to supply $26 million for the project. The sought after DOE money is part of a $750 million fund established by Congress for the development of clean coal technologies. 25/

Weirton Steel Corp., in conjunction with the State of West Virginia and and West Virginian coal producers, is also applying for DOE help in constructing a KR ironmaking facility. Weirton is requesting $65 million from DOE, and

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24/ Lautenschlager, Scott. Funds Sought for KR Process Plant. AMM, May 24, 1985. p. 1, 7.

25/ Ibid.

estimates that the project will cost $126.6 million to build and operate the plant for one year. 26/

Japanese steelmakers are also actively pursuing ironmaking processes which like the KR process, would replace the blast furnace and eliminate the need for metallurgical coke. Sumitomo Metal Industries, Ltd. plans to start constructing a demonstration plant in 1985 which would use pulverized noncoking coal as fuel, and reduce the cost of making pig iron by 10 percent. If tests are successful, the company hopes to install the new facility and replace one of its existing blast furnaces in 1989. Nippon Steel and Kawasaki Steel are developing similar processes. 27/

EXPLORATORY STAGE OF DEVELOPMENT

This stage includes direct casting and direct steelmaking, technologies which are not yet fully ready for commercial application. Because of the potential benefits they offer, efforts to develop these technologies are being pursued throughout the world.

Direct Casting

A sizeable amount of Federal funding is being directed towards the development of a caster that yields near net shape thin strip and sheet. Such a capability would eliminate or greatly reduce the need for a hot rolling operation.

DOE currently is funding the development of two different direct casting technologies. In 1984, DOE awarded a five year, $28.8 million contract to

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26/ Lautenschlager, Scott. Weirton Seeks Federal Funds for Iron Plant. AMM, June 5, 1985. p. 1, 7.

27/ Steel Companies Announce Plans for New Processes. Tokyo Kyodo, Mar. 20, 1985. In: Japan Report, May 30, 1985. p. 113.

U.S. Steel and Bethlehem Steel for the development of a commercially feasible twin belt direct casting system. A pilot plant in Universal, Pennsylvania, will be constructed to test the process. The companies plan to use two moving belts to cast steel slabs to approximately one half to one inch in thickness. The steel can then be hot rolled down to 0.1 inches, a thickness required for subsequent processing into finished steel sheet. Conventionally, continuously cast slabs of about 10 inches in thickness are hot rolled all the way down to approximately 0.1 inches. Thus, with this process, only a fraction of the hot rolling normally required is performed. In addition, it is intended that the caster will produce high surface quality sheet with suitable properties for automobile body applications. 28/

Armco Inc. and Westinghouse Electric Corp. are looking at a process that is more long-term and high risk than twin belt casting. They aim to eliminate completely the need for hot rolling by casting strips directly to thicknesses of 0.03 to 0.125 inches. Research is proceeding under a $2.6 million DOE contract.

In the Armco-Westinghouse process, molten metal is rapidly solidified into a thin strip on a large water cooled wheel. An experimental caster will be located at Armco's Middletown, Ohio, works. If the two year experimental program is successful, company sponsors hope that a pilot facility may eventually be built. An Armco official has estimated that commercialization is possible in six to eight years. 29/

Other domestic steelmakers have independently embarked on direct casting projects. In September 1984 Allegheny Ludlum Steel Corp. announced

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28/ Meschter, Elwood. Nucor likely the first in commercial output. AMM, Sept. 23, 1985. p. 3A.

29/ LaRue, Gloria T. In the Offing: Direct Cast. AMM, Sept. 23, 1985. p. 3A.

it has developed a direct casting process for stainless steel. During the past six years the company has spent approximately $7 million to develop a process that can cast molten stainless steel into strips thinner than 0.083 inches. The company is building a pilot plant near Buffalo, New York, in an effort to scale up the process to production levels (5000 pound coils in widths up to 24 inches). Currently, 500-pound, 12-inch wide coils of stainless strip have been successfully cast. 30/ Company officials estimate that the process could be commercialized within three years. It would be used only for light-gauge sheet stainless steels. 31/

Nucor Corp., a leading minimill company, has also recently announced plans to scale up a direct slab caster to production levels. Direct casting of steel sheet holds a special attraction for minimills because it would allow them to enter the extensive sheet product market. Currently, minimills specialize in bars, wires, rods, and other structural shapes. Conventional production of steel sheet would require over $300 million in rolling facilities--an investment that minimills generally cannot afford. 32/

Nucor will begin testing a thin slab caster at its Darlington, South Carolina, mill in the fall of 1986. If successful, the caster will become part of a brand new flat rolled minimill that could go on stream by late 1988 or 1989. 33/

30/ McManus, George. HP Stainless Helps Car Makers. Iron Age, Apr. 5, 1985. p. 52-53.

31/ LaRue, Gloria T. In the Offing: Direct Cast. AMM, Sept. 23, 1985. p. 14A.

32/ Howard, Hi. Minis Need Radically New Technology To Make Sheet. Dec. 6, 1983. p. 10.

33/ Yafie, Roberta C. Nucor Takes Step Toward Flat-Roll Mill. AMM, June 6, 1985. p. 1.

Like the U.S. Steel-Bethlehem direct casting project, Nucor plans to cast slabs to an intermediate thickness, and then roll the steel down to a sheet gage. The caster will produce slabs that are 1.5 inches thick and 52 inches wide at a rate of 350,000 to 400,000 tons per year. Low quality sheet markets such as decking, siding, and oil drums will be targeted. 34/

Since 1983, National Steel Corp. has been working with Battelle Institute to develop a thin strip caster. In this process, molten metal is dragged onto a cooled rotating wheel which instantly solidifies the metal. A steel strip of uniform thickness and width is produced that would be suitable for applications requiring non-critical surface and metallurgical properties. Reportedly, the project is one to three years from the pilot plant stage. 35/

Interest in direct casting is certainly not confined to the United States. Research is particularly widespread in Japan. According to a study prepared by General Electric for DOE:

> Several Japanese steel companies and at least one equipment manufacturer have been actively working for the last five years on at least three different direct casting processes . . . With reference to the twin belt process, at least two steel companies now have pilot plants. One of these companies is teamed with Hitachi Ltd., who has reportedly been working on the development of a twin belt casting machine for the last two years. 1.6 inch thick (possibly thinner) X 24 inch wide slab has been cast from low carbon steel at 16 feet/minute . . . . In any event, it appears that we may see commercial production in Japan by new direct casting processes in the next 3-6 years. 36/

34/ Ibid.

35/ LaRue, Gloria T. In the Offing: Direct Cast. AMM, Sept. 23, 1985. p. 3A.

36/ Desai, J. D. Technology Development of Thin Strip Metal Casting--Feasibility Study. Prepared for Office of Industrial Programs, U.S. Dept. of Energy. Jan. 1984. p. A-49.

General Electric also reports that the Iron and Steel Institute of Japan formed a special committee in April 1984 to study direct casting processes based on rapid solidification. [37]

As indicated by the flurry of activity surrounding direct casting both in the United States and abroad, the process seems to be a coming reality. But it must be recognized that direct casting can refer to two very different approaches. Twin belt casters which produce thin slabs with thicknesses on the order of 1 inch (e.g. the U.S. Steel-Bethlehem project) could be commercialized by the end of the decade. Direct casting processes employing a water cooled casting wheel (such as the Armco-Westinghouse process) would directly produce sheet or strip under a tenth of an inch thick. Although potential benefits are greater than those of twin-belt casting, the technical obstacles to its successful development are more formidable.

Direct Steelmaking

Direct steelmaking is the conversion of iron ore to liquid steel in a single reactor system. There are major technical problems inherent in combining the ironmaking and steelmaking operation in a single vessel. OTA addressed some barriers to the successful realization of direct steelmaking in its report, Technology and Steel Industry Competitiveness:

> The idea of going from oxide concentrate directly to steel in a continuous, smooth operation has excited imaginations for many years. Europeans, Americans, and many others have spent a great deal of money on small pilot efforts, but none of these efforts has been particularly successful from a research standpoint, and none has been carried to commercial scale. The problem has been that the different functions cannot be isolated properly: all the equipment must be tied up in a single strand, and the system has

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[37] Ibid., p. A-50.

> little flexibility with respect to either process variables or product requirements. 38/

OTA adds that it is "very unlikely that any direct, continuous single-reactor process will assume commercial significance in the next decade." 39/

At Argonne National Laboratory, DOE plans to investigate the direct production of liquid steel from iron ore. This effort is part of the "Keyworth Initiative" to develop "leapfrog technologies." This initiative will be discussed in Section VI of this paper.

Overseas, Kloeckner Steel Corp. of West Germany is also investigating a process related to direct steelmaking. Kloeckner will try to make liquid steel directly from a mixture of coal, oxygen, iron ore and scrap. Essentially, the process is a compromise between direct steelmaking and the rapid refining of steel scrap. More testing is needed before Kloeckner can determine whether the process is feasible--definitive pilot plant results are one or two years away. 40/

38/ OTA, Technology and Steel Industry Competitiveness, p. 209.

39/ Ibid.

40/ Private communication, Office of Industrial Programs, U.S. Dept. of Energy.

VI. LEAPFROG TECHNOLOGIES AND COMPETITIVENESS

Many of the new technologies mentioned in this report are either implemented, researched, or contemplated by steel companies throughout the world. In fact, most were developed or first commercialized overseas. With this in mind, some observers have asserted that adopting existing technologies alone will not provide the domestic industry with a competitive advantage. Although it will put the industry on an equal technological footing with foreign producers, it is questionable that merely adopting foreign technologies will compensate for other competitive advantages (i.e. labor costs, energy costs, etc.) that foreign steelmakers may enjoy.

Howard Love, president of National Steel, addressed this concern in a February 1984 presentation to the Presidential Committee on Industrial Competitiveness (PCIC):

> . . . merely catching up by duplicating the competition's technology will not solve the problem. We must leapfrog the state-of-the-art technology being installed today by Third World powers. 41/

The term "leapfrog technology" refers more to a concept or philosophy than to any one specific steelmaking technology. The idea is to develop radically new, American-bred technologies which are not available anywhere else in the world. Mr. Love spoke of creating a domestic industry "where we throw away the blast furnaces, throw away coke ovens, and develop entirely

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41/ Bowers, Edwin W. Steel in Search of Leapfrog Technology. Iron Age, Apr. 2, 1984. p. 62.

new ways of making a higher quality, higher yield product, at smaller scales, with greater flexibility and more automation." 42/

The attractiveness of "leapfrog" is based on a belief in the supremacy of American science and technology. Mr. Love's remarks suggest the potential for a "technological fix" to competitive problems of the domestic steel industry:

> Let me also stress that by seeking a technological solution, we are building upon our national strengths. We can't compete with the third world on the cost of labor or capital. The one thing we have in our favor is the best science and technology base in the world. Let's take advantage of the base; let's utilize it for the benefit of our basic industries. 43/

A specific approach which could be used to harness the nation's technological strength was suggested by the May 1983 report of the White House Science Council's Federal Laboratory Review Panel (known as the "Packard Report"). The report strongly recommended greater collaboration between the federal laboratories and industry.

Subsequently Dr. George Keyworth, Science Advisor to the President and Director of the Office of Science and Technology Policy, endorsed what is now known as the "Steel Initiative," that is, utilizing the expertise and facilities of the National Laboratories to develop next-generation steelmaking technologies of a "leapfrog" nature.

42/ Ibid., p. 63.

43/ U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research and Technology. 1986 National Bureau of Standards Authorization. Hearing, 99th Cong., 1st sess., Mar. 6, 1985. Washington, U.S. Govt. Print. Off., 1985. p. 435. (Hereafter cited as NBS Authorization Hearings)

RESEARCH AGENDA OF THE STEEL INITIATIVE

A series of meetings in 1984 between representatives of the steel industry, the national laboratories, government agencies, and universities resulted in the selection of two high priority areas of research which were deemed to be well suited for the collaborative industry-national lab approach. These are: the direct production of liquid steel from iron ore (direct steelmaking), and the direct casting of near net shape solids.

Argonne National Laboratory along with Oak Ridge National Laboratory and the National Bureau of Standards were designated as the primary federal research laboratories responsible for implementing the Steel Initiative. By the end of 1984, a Steel Initiative steering committee (composed of vice presidents for research of several steel companies and representatives of Argonne, Oak Ridge, and NBS) had put together a detailed work plan which included cost estimates for the overall research program. The steering committee recommended a Federal funding level of $12 million in FY1986 and an industry contribution of about $3 million. The steel industry donation to the Steel Initiative would mainly come in the form of industry engineering personnel who would work side-by-side with government researchers on the project. It is envisioned that such an arrangement would lend a practical real-world orientation to the project and also facilitate the transfer of new technology back to the steel plants.

The following sections will examine the two "leapfrog" technologies which currently comprise the Steel Initiative, and the sensor program at NBS.

Task A: Direct Production of Liquid Steel From Iron Ore

The ideal result of this research project, to be conducted at Argonne National Laboratory, would be the commercialization of a process in 10 to 15 years which would economically convert domestic iron ores (or scrap) and coals into liquid steel. Such a process would replace three primary stages of the steelmaking process--the coke oven, the blast furnace, and the steelmaking furnace--and would yield a 50 percent reduction in capital costs and a 30 percent reduction in operating and maintenance costs. The primary end is attractive for modification since it represents almost half the cost of finished steel and about 75 percent of the energy intensity. 44/

It is not yet known which particular direct steelmaking process could deliver these results, or indeed, if such a process is feasible. Less ambitious variations of the direct steelmaking process include those which directly smelt iron ore and coal into liquid iron (such as the KR process) or those which convert scrap and coal into liquid steel (such as the energy optimizing furnace or the KS process). Although some of these technologies have reached the pilot plant stage overseas or even limited commercial development, none have yet proven to be technologically and economically viable for the domestic steel industry.

Many of the direct smelting processes developed in foreign countries are designed to take advantage of feedstocks that are indigenous to those countries. For this reason, Steel Initiative planners are particularly interested in direct steelmaking from scrap processes which would take advantage of the United States' world-leading resource of scrap:

> It has become apparent in the development of the research program under Task A that the very large domestic inventory of iron and steel scrap represents a major raw materials resource for the U.S. More significantly, this resource base is not shared by most of the foreign steel producers who currently compete most aggressively for the U.S. market. Thus, a direct steelmaking process utilizing scrap as the feedstock offers significant competitive advantages to the American

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44/ Testimony of Frank Luerssen before the House Committee on Science and Technology. July 17, 1985.

steel industry relative to most of the foreign competition. For this reason, direct steelmaking from scrap has been added to the carbothermal direct steelmaking from iron ore. 45/

A comprehensive review of state-of-the-art direct iron and steelmaking technologies was recently conducted by the General Research Committee of the American Iron and Steel Institute. Approximately 12 technologies were identified as being especially promising. The Steel Initiative "iron ore to liquid steel" research project seeks to use computer modelling and simulation to select a best overall process for further experimental development. The optimized process selected may be a modification of an existing technology, or perhaps a hybrid of several direct process technologies. If feasibility studies prove that pilot plant construction is warranted, the overall cost of the pilot plant is estimated to be $45 million, plus $30 million for operation over three years.

Besides systematically identifying a single most promising process which will subsequently be developed experimentally, the project will also conduct research geared towards solving some generic technical problems which are common to many direct iron and steelmaking processes. For example, most of these processes involve violent chemical reactions at extremely high temperatures. Refractory materials used to contain these reactions often have trouble withstanding the harsh environment of gases, slags, and molten iron that is produced. Since this problem presents a major obstacle to the successful development of many of these technologies, researchers will try to develop

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45/ John Roberts, Associate Laboratory Director, Argonne National Laboratory. U.S. Congress. House. Committee on Science and Technology. Subcommittees on Energy Development and Applications and on Science, Research and Technology. Steel Initiative. Hearings, 99th Cong., 1st sess., July 17, 1985. Washington, U.S. Govt. Print. Off., 1985. p. 135. [Hereafter cited as House Science and Technology Committee, Steel Initiative] improved refractory materials, modified process configurations, or even noncontacting process containment schemes such as electromagnetic confinement.

Another aspect of the program, distinct from the selection of an optimized direct process for the mid-term (10 to 15 years), is the investigation of more innovative and long term direct iron and steelmaking technologies. Those which will be explored include: electrochemical refining, plasma processes, alternative chemical synthesis approaches, biomining, and biorefining. It is felt that feasibility studies of these extremely innovative technologies could conceivably lead to commercially viable processes at some time beyond the year 2000.

Task B: Continuous Casting of Near Net Shape Solids

The major focus of this task is the development of an electromagnetic continuous casting process for steel. Whereas Task A still must select a promising technology for further development, Task B is more advanced to the extent that it has already identified a "candidate technology" which may satisfy its objectives.

On a general level, electromagnetic casting is similar to the direct casting technologies previously mentioned in this report (i.e. twin belt and rapid solidification processes). All seek to cast liquid steel directly into thin sheet or strip. An important difference, however, is that electromagnetic casting is a "moldless" process that could directly cast sheet at commercial thicknesses (0.25 inches or less). In other casting processes, liquid steel must come in contact with molds, which often produces defects in the cast metal.

By contrast, electromagnetic casting involves pouring hot metal into a carefully shaped magnetic field rather than into a mold. Dr. John Roberts, Associate Laboratory Director at Argonne National Laboratory depicts the process as "an invisible, perfectly flat table on which one can continuously cast wide, thin sheets of near-finished steel product." 46/ According to Dr. Roberts, the technology offers the potential of a 10 percent reduction in energy costs compared to the traditional route of casting thick slabs and rolling them into thin sheet or strips. 47/

The aluminum industry currently uses electromagnetic casting as a batch process. However, there is much greater difficulty in using electromagnetic fields to continuously cast steel because liquid steel has a higher temperature and density than liquid aluminum.

The development of electromagnetic casting technology for the steel industry would take place at Argonne and involve three phases: 1) feasibility studies and proof of concept experimentation; 2) laboratory-scale experiments which would validate the concept and provide engineering data; and 3) pilot plant demonstration of the process.

In testimony before the House Subcommittees on Science, Research and Technology and Energy Development and Applications, Dr. Roberts estimated the cost for the first two phases at $25 million of DOE funding with an additional 15 to 20 percent provided by the steel industry. Pilot plant facilities would cost approximately $30 million for design and construction plus $6 to 10 million per year for operation over a three year period. 48/

A related goal of Task B is the development of thermal and mechanical processes which can impart to directly cast sheet the properties and

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46/ Testimony of John J. Roberts before the House Committee on Science and Technology. July 17, 1985.

47/ Ibid.

48/ Ibid.

characteristics that steel applications require. Dr. Alexander Zucker, Associate Director for Physical Sciences at the Oak Ridge National Laboratory, explained the need for new thermomechanical processing technology in testimony before the House Science and Technology Committee:

> Current technology has been carefully developed in an evolutionary manner over the past 50 years to produce a variety of steel products to meet the requirements of steel industry customers. The new near-net-shape technology poses entirely different problems. The 1/2 inch steel must be reduced to much thinner material, usually less than 0.1 inch, and through this reduction the steel must develop properties needed for particular applications. The desired properties include strength, fabricability, surface smoothness, uniformity, toughness, and many others. In the new technology to be developed by the Steel Initiative, totally new sequences of thermal and mechanical processes will be needed to develop the desired properties in the new steel. 49/

Researchers at ORNL plan to construct a laboratory-scale thermomechanical simulator which would be available to steel companies for developing different grades of steel for their customers. An important objective of the project is the development of universal grades of steel. According to Dr. Zucker:

> The steel companies currently sell several thousands of grades of steel to meet the needs of their customers. This is accomplished largely by compositional modifications or control and only slightly by processing variations. In the new technology, processing will be emphasized to a greater extent. This will allow us to develop a few universal grades of steel in which a wide envelope of properties can be developed through processing variations. Again, the steel companies will work with their customers to develop steels for particular applications and the laboratories will develop the technology base on which the steel companies will operate. The development of a few universal compositions on which properties are varied through processing controls will substantially reduce inventory and management costs. 50/

The estimated cost for the development of thermomechanical processing technology at ORNL is $3.35 million in FY1986, $4.3 million in FY1987 and $2 million in FY1988. ORNL also proposes to develop a ceramic filter for

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49/ Testimony of Alexander Zucker before the House Committee on Science and Technology. July 17, 1985.

50/ Ibid.

removing nonmetallic inclusions which often degrade the quality of cast steel. For this activity, the lab is proposing a budget of $1.935 million for fiscal years 1986 through 1988.

A key objective of both Task A (converting raw materials directly into liquid steel) and Task B (converting liquid steel directly into cast shapes) is to streamline the steelmaking process by eliminating costly or obsolete stages of production. Obviously, any amount of success in these efforts would translate into lower operating costs. However, electromagnetic casting coupled with thermomechanical processing could conceivably offer an additional benefit which reflects the steel industry's growing emphasis on product quality. Researchers hope that the technology will allow greater control over the relationship between process and product. Such control could result in the production of higher quality steel (with better properties) which could be targeted towards specific applications and markets.

Frank Luerssen, Chairman and Chief Executive Officer of Inland Steel Company, cited the importance of product quality and capability in testimony before the House Science and Technology Committee:

> Steel companies are aggressively seeking increased profitability through the development of differentiated products: steels that provide more value per ton to customers because of their unique ability to meet a need. These steels command premium prices in the market and result in improved profitability margins. 51/

Another factor which has focused attention on the steel product and its properties is the growing use of nonmetallic materials which have displaced steel in some markets. For example, in certain applications a plastic, ceramic, or composite may offer superior properties at a comparable cost.

51/ Testimony of Frank Luerssen before the House Committee on Science and Technology. July 17, 1985.

Sensor Program at the National Bureau of Standards

Process control sensors are devices which can relay physical and chemical data about a manufacturing process while in progress. These data can then be used to adjust process parameters in order to optimize productivity and quality.

In 1982, the American Iron and Steel Institute and the National Bureau of Standards jointly identified four high priority sensor needs of the domestic steel industry. These are: Rapid Measurement of Temperature Distribution Within a Solid or Solidifying Body of Hot Steel (measuring internal temperature without penetrating the material); Automatic Detection of Pipe and Gross Porosity in Hot Steel Billets, Blooms or Slabs (assuring the absence of voids inside the hot steel before it is processed into finished product); Rapid In-Process Analysis of Molten Metal (measuring the chemical composition of the molten metal so that it can be rapidly adjusted to specifications through controlled alloy additions); and On-Line Inspection of Surface Defects on Hot and Cold Strip (identifying and classifying surface imperfections in sheet steels while they are moving at speeds up to 6,000 feet per minute). 52/

Research on two of these needs, internal temperature and porosity sensors, is being conducted at NBS, with industry scientists working onsite with government researchers. Porosity sensors have reached the prototype stage. They will be tested at Argonne and evaluated by NBS researchers.

Sensors can be viewed as tools to increase the efficiency of different parts of the steelmaking process. Also, much of the sensor work constitutes a necessary underpinning for the successful development of Steel Initiative technologies.

52/ Leonard, James H., Vice President, Technology, Bethlehem Steel Corp. NBS Authorization Hearings. p. 427.

WILL THE STEEL INITIATIVE ENHANCE COMPETITIVENESS?

At face value, the attractiveness of the Steel Initiative, with its promise of massive cost savings and superior product quality, seems compelling. Certainly, the notion that American science and technology could endow the domestic steel industry with a competitive edge is a goal few would object to. However there are some cautions, qualifications, and criticisms of the Steel Inititative that should be considered. Questions have been raised about the general philosophy behind "leapfrog technologies" and about the approach of the specific research programs themselves.

Can Leapfrog Technologies be Kept at Home?

The philosophy behind the Steel Initiative is that the Federal Government should help domestic industry "leapfrog" state-of-the-art technologies currently used throughout the world. Ideally, the steel industry would then have powerful technologies at its disposal which would be unavailable to foreign competitors.

Some observers wonder whether it will be possible to keep new technologies "at home" and ask how long any advances in steelmaking could be prevented from spreading throughout the world. Current steel technology flows freely among the world's steel companies. Richard Pitler of Allegheny Ludlum Steel Corp. emphasized this point at a minerals economics symposium sponsored by the American Institute of Mining, Metallurgical and Petroleum Engineers:

> Have no doubt that technology in the steel industry is available to anyone worldwide. There are no technological secrets, and whoever has the capital assets to deploy technology will use the best available technology first and therefore be the most competitive industry. 53/

53/ Pitler, R. K. Steel Industry Process Technology Trends. Materials and Society, vol. 9, no. 2, 1985. p. 151.

Once commercialized, steel technologies spread quickly. A study done for AISI in the late seventies found that historically, most new technologies were adopted by others within 2 to 4 years of their first commercial use. 54/

Steel Initiative research cannot be fully concealed under a proprietary shield since it relies on federal funding and involves the participation of many domestic steel companies. Also, it is unlikely that steelmaking research could be protected by national security classifications. The problem grows more complex when one notes that AISI, the steel industry group behind the Steel Initiative, contains Canadian member companies as well as American member companies which are partially owned by Japanese firms (i.e. 50 percent of National Steel is owned by Nippon Kokan).

Government and industry officials connected with the Steel Initiative concede that keeping new steel technologies domestic is a difficult problem that requires further examination. For now, they will rely on the discretion of all participants in the project, and they will try to limit the distribution of technical reports.

Some assert that even if promising technologies do leak overseas, the domestic industries will at least have a "head start" towards implementing them. The OTA report, Technology and Steel Industry Competitiveness, cautioned against a strategy for competitiveness that is confined to adopting innovation from foreign sources:

> . . . whatever new technology is purchased from foreign sources still leaves the purchaser one step behind the originator. By the time all is learned about the innovation, the foreign source is well on its way to exploiting the next one. It may be true that there is equality of knowledge among the world steel industries concerning fundamental innovations, yet it is an error to believe that knowledge about

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54/ Pitler, Richard K. Worldwide Technological Developments and their Adoption by the Steel Industry in the United States. Paper presented at the 1977 Annual Meeting of the American Iron and Steel Institute. May 26, 1977. p. 33.

> innovations is equivalent to innovating. Waiting to use someone else's innovation is a strategy likely to spell competitive loss in the long run. It takes years for steel plants to be designed and built, and those who innovate tend to stay ahead of their competitors. 55/

Steel Initiative supporters could argue that this warning would be equally valid for foreign steelmakers, who would seek to adopt American innovations which had already been commercialized by domestic steel companies.

Frank Luerssen points out that if new technologies are exclusively geared towards American resources and needs, foreign adoption of these technologies may not be a problem:

> Although formal means, such as patents, may be useful in some instances to restrict the results of the initiative, by far the best way in the long run is to develop technology that takes advantage of unique domestic attributes. Then, although foreign competitors may be aware of the technology, it would not be to their economic advantage to utilize it. 56/

As discussed earlier, the development of direct steelmaking processes that utilize scrap could be viewed as an opportunity to take advantage of a "unique domestic attribute."

U.S. Steelmaking R&D Capability

The "leapfrog" philosophy is based on the premise that American science and technology is the best in the world. It logically follows that the development of unique steelmaking technologies is dependent on an outstanding steelmaking R & D capability.

Whether or not American science and technology enjoys worldwide preeminence is well beyond the scope of this paper. However, there are

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55/ OTA, Technology and Steel Industry Competitiveness, p. 269.

56/ House Science and Technology Committee, Steel Initiative, p. 148.

some ideas and issues about U.S. steelmaking R&D capability which may be useful to consider.

The National Academy of Engineering (NAE), in its report, The Competitive Status of the U.S. Steel Industry, evaluated the R&D capabilities of the United States by comparing the numbers of research scientists and engineers among major steel producing nations. The NAE report concluded:

> It is apparent . . . that Japan is now leading the world in size of ferrous metal R&D activities . . . The United States, the leader in the 1950s, is now second in size of effort. In the opinion of U.S. experts who have recently visited Japanese laboratories, Japan now surpasses the United States in theoretical and applied physical metallurgy as well as process metallurgy. 57/

While no one would dispute the fact that U.S. steel R&D has generally lagged behind foreign steel R&D, one could argue that the Steel Initiative is an effort to remedy this situation by matching outstanding national research facilities and expertise with specific research needs. For example, Argonne National Laboratory (which proposes to develop an electromagnetic caster) has a world-class capability for the design, construction, and testing of state-of-the-art magnetic devices. Oak Ridge (which is involved in thermomechanical processing) has extensive experience in metal casting and processing, and the study of the relationship between a material's microstructure and properties. According to Alexander Zucker, "the Laboratories with their multidisciplinary capability are probably the only places in the country that can on short order assemble the staff, develop program plans, and manage a large cooperative research effort." 58/

57/ National Academy of Engineering. National Research Council. The Competitive Status of the U.S. Steel Industry. Washington, National Academy Press, 1985. p. 41-42.

58/ Testimony of Alexander Zucker before the House Committee on Science and Technology. July 17, 1985.

There has been criticism, however, that Steel Initiative funding for the National Laboratories may drain away support for basic steel research activities at the nation's universities. Some argue that because the National Labs have little specific experience in steelmaking research, they will need help determining fruitful research paths and approaches. And since steel industry basic R&D has been scant in recent years, university expertise will be needed. Dr. Richard Fruehan, Professor and Director of the Center for Iron and Steelmaking Research at Carnegie-Mellon University, presented this position to the House Committee on Science and Technology:

> It should be stressed that because of the enormous cost of pilot plants before any pilot plant studies are begun we must fully understand all of the basic science . . . The program thrust areas should be clearly defined. Areas such as direct steelmaking and new casting technologies are obviously needed. In these areas certain basic information is required to assist any development. For example, in many new ironmaking techniques there are reactions between particles of iron oxide, coal and hot gases; these reactions must be fully understood. Other examples include containment of metal during processing by refractory type materials and electromagnetics, and fluid flow and mass transfer in processing vessels. These fundamental areas should be defined and work should start as soon as possible so that the knowledge will be available during the latter stages of development. 59/

Although it is expected that much Steel Initiative research will be subcontracted to universities, Dr. Fruehan argued that a "definite legislated percentage of the work should be contracted to universities" because of their expertise in basic research in steelmaking, and in order to train technical personnel needed for the future.

59/ Testimony of Richard Fruehan before the House Committee on Science and Technology. July 17. 1985.

High Payoff vs. High-Risk

Any anticipation of the substantial payoffs promised by Steel Initiative technologies should be tempered by the realization that these technologies are long-term and high-risk. Leapfrog technologies are, at the very least, 10 to 15 years away and some observers point out that unless the industry receives shorter term help, radically new technologies of the future may come too late. According to Frank Luersson, president of Inland Steel:

> It will be at least ten years before any element of these projects could be commercial. In this interim period the steel industry must improve its financial structure significantly to assume the capability it must have to exploit the technology anticipated from the Keyworth Initiative. 60/

The NAE report, The Competitive Status of the U.S. Steel Industry argues that shorter term, incremental-type technologies may be more helpful than long-term radical technologies:

> There do not appear to be great prospects for any radically new technologies that would be the salvation of the domestic integrated steel industry. Rather, the important factors will probably be incremental technological advances to reduce production costs, improve product quality, and increase services. 61/

DOE Objections: Cost and Appropriateness

The President's Office of Science and Technology Policy (OSTP) was an original supporter of the Steel Initiative. However, the Administration's 1986 budget included no funds for this program in the DOE or NBS budgets.

60/ Testimony of Frank Luerssen before the House Committee on Science and Technology. July 17, 1985.

61/ National Academy of Engineering. National Research Council. The Competitive Status of the U.S. Steel Industry. Washington, National Academy Press, 1985. p. 44.

There is currently legislation in Congress that seeks to provide funding for the Steel Initiative.

At hearings before the House Science and Technology Committee on July 17, 1985, DOE expressed its concerns about the Steel Initiative. DOE objections center on both the cost of the program and the project's appropriateness for DOE involvement.

Concerning cost, DOE states that while the initial federal cost of the program would be $25 million for two years, any costs required after the first two years are likely to be excessive. DOE claims that its experience with similar research programs indicates that costs greatly expand once new technologies enter the scale-up stage. Also at this point, pressure usually increases for more and more federal involvement. DOE estimates that the total cost of the Steel Initiative could range from $200 million to $1 billion over 15 or more years, and DOE doubts that the domestic steel industry will be willing or able to assume a significant portion of these costs. According to DOE, the risks of failure and the benefits of technical success have not been adequately evaluated and weighed against the costs of the program.

There is also the question of appropriateness. DOE characterizes the Steel Initiative as a broad generic research program that touches on areas (such as international competitiveness) which fall outside of DOE's organizational responsibility to focus exclusively on energy matters. Additionally, DOE claims that it funds ongoing programs (such as the U.S. Steel - Bethlehem direct casting program and the KR process assessment), which, though narrower in scope, include many of the same technological objectives as the Steel Initiative.

Leapfrog Technologies: Will they be useful? Will they be used?

Like any high-risk, long-term research pursuit, there are no guarantees that the Steel Initiative will fully accomplish its goals. But even if these technologies can be developed, and even if they can provide domestic steelmakers with a unique technological advantage over their foreign competitors, two very significant questions still must be considered. First: will the technological advantage derived from the Steel Initiative be enough to compensate for the economic advantages that foreign producers currently enjoy?

And second, and perhaps more importantly: will domestic steel companies have the necessary capital to implement these new technologies when they become commercially viable? William Dennis, vice president of manufacturing and research at AISI, recently voiced this concern in response to a question on whether the steel industry was placing too much priority on the trade issue at the expense of focusing on radically new technologies:

> It is important to understand that, if we develop ambitious programs for the development of new technology without improving the industry's prospects for capital formation and solving the problem of unfair trade in steel, we will still be out of business as an industry. The only result would be the provision of free technical information to foreign producers. This would simply reduce the subsidies which foreign governments are supplying to maintain state-of-the-art steel plants. The annual Deming Award in Japan for quality is quite enough. An annual Keyworth Award in Japan for their steel company most successful implementing our technology would be more than most of us could bear. 62/

62/ Miller, J. R. The American Steel Industry's Program for Research and Development. Iron & Steelmaker, Oct. 1984.

VII. CONCLUSIONS

This report discusses an assortment of new steelmaking technologies with respect to three different criteria: the benefits they offer, the stage of production with which each technology can be associated, and their respective stages of development. When applying these criteria to specific technologies, themes or trends emerge which bring the relationship between technology and competitiveness into sharper focus.

For example, it has been seen that major benefits of new technologies include increased productivity, accompanied by a growing emphasis on improved product quality. Naturally, the spiraling import penetration by foreign competitors sparks interest in lowering the costs of production. Also, a trend of shrinking markets, caused in part by the rising use of nonmetallic materials in traditional steel applications, has led steelmakers to seek technologies which enable them to consciously gear products to specific market applications.

The thrust of the Steel Initiative technologies reflects these concerns. Both Task A (raw materials to liquid steel) and Task B (liquid steel to near net shapes) seek to drastically cut production costs. Additionally, the thermomechanical processing technology envisioned under Task B focuses on the quality and characteristics of the product produced. Interestingly, as new technology becomes more end-product oriented, the collaborative approach of the Steel Initiative may become more problematic, since each individual company must compete at selling proprietary products.

Relating new technologies to stages of production can be used to understand how new technologies might increase productivity, and to assess their prominence in future steelmaking operations. For instance, the sought after technologies in the Steel Initiative program derive their attractiveness through their potential for consolidating or eliminating major stages of production in the steel manufacturing process. Direct steelmaking (Task A) would exclude the coke oven, blast furnace, and possibly the electric or basic oxygen steelmaking furnace. Similarly, direct casting (Task B) targets the hot rolling operation for elimination.

Some industry observers have predicted a trend in which the "hot end" of the steelmaking process will be phased out, while reliance on imported semifinished steel will increase. 63/ (The "hot end" refers to the initial stages of steel production which are more energy and raw materials intensive than the finishing end of the cycle.) If this prediction comes true, new technologies that are associated with the finishing end might attract an increasing amount of interest, and the utility of radical Steel Initiative technologies would diminish. (A semifinished steel slab, for example, has already gone through the raw materials preparation, ironmaking, steelmaking, and casting stages.) It is hoped, however, that the implementation of innovative technologies will allow domestic producers to use inexpensive coal, iron ore, and scrap to produce economically their own semifinished steel.

Finally, new technologies can be grouped into three general stages of development: widely commercialized or adopted, preliminary stages of commercialization, and exploratory stage of development. In terms of competitiveness, the first two stages encompass technologies which, in general, are more widely adopted or developed overseas, and the domestic steel industry must strive to "catch up" in order to remain competitive. The third (exploratory) stage

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63/ McManus, George. Steel's Agony. Iron Age, May 17, 1985. p. 20.

involves the so-called "leapfrog technologies" of the Steel Initiative which seek to further bolster competitiveness by establishing a unique technological advantage among domestic steelmakers.

Some considerations and criticisms concerning "leapfrog" have been presented, and they involve: the feasibility of keeping technologies from spreading to foreign competitiors, steel R&D capabilities and approaches, incremental vs. radical long term technologies, cost, and appropriateness for Federal involvement. The point that seems to emanate from these factors may be that the competitive value of a new technology is not necessarily assured by developing that particular technology before anyone else does -- successfully developing a new process will not necessarily improve the industry's competitive position unless that process fits in with economic, geopolitical, regulatory and/or other trends that affect the viability of domestic steelmakers.

The idea that technological factors cannot be separated from the many other factors that will shape the future of the steel industry is reflected in the two key questions that accompany consideration of the Steel Initiative and its potential contribution to steel industry competitiveness. First, will technological advantages compensate for economic advantages that foreign producers enjoy? And second, will domestic companies have the money needed to implement these new technologies? The answers to these questions will be affected not only by Federal policies on R&D, but also by policies on trade, the budget deficit, antitrust laws, tax laws, environmental regulation, and other far-reaching areas.

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APPENDIX : HOW STEEL IS MADE

TECHNOLOGY

Processing

Ironmaking —As shown in figure 1, iron is produced from ore either by blast furnaces or by one of several direct reduction processes. Although direct reduction has been used successfully in certain locations, blast furnace operations continue to produce the bulk of the world's iron.

The modern blast furnace resembles its forerunners in its essentials. It consists of a refractory-lined steel shaft in which the charge is continuously added to the top through a gas seal, and preheated air is blown through the tuyeres at the bosh near the bottom, to be emitted as combustible gas (top gas). Iron and slag are intermittently tapped from the hearth at the bottom. The furnace has high thermal efficiency because of the countercurrent flow of solids descending and hot gases rising from the combustion zone and transferring their heat to the charge. The charge consists principally of iron ore, sinter or pellets, coke, and limestone or dolomite; iron and steel scrap may be added in small amounts. The chemical reactions are complex; the main reactions are combustion of coke to produce carbon monoxide, reduction of the iron ore to iron by the carbon monoxide, and fluxing of the silica and alumina in the ore and coke ash with limestone to form a slag that absorbs much of the sulfur from the charge.

Preheated air up to 2,000° F for the furnace is supplied by refractory-lined, checker-brick stoves heated by burning cleaned top gas. The molten pig iron, which has dissolved some carbon and silicon, is generally tapped into a transfer ladle, which delivers the hot metal to the steelmaking plant. The metal may also be cast into pigs for subsequent sale or use. Slag is tapped into ladle cars for hauling to the slag dump, allowed to solidify in a slag pit, or granulated with water. Blast furnace slag is used for concrete aggregate, railroad ballast, soil conditioner or landfill.

Source: U.S. Bureau of Mines, Mineral Facts and Problems, 1985 Edition

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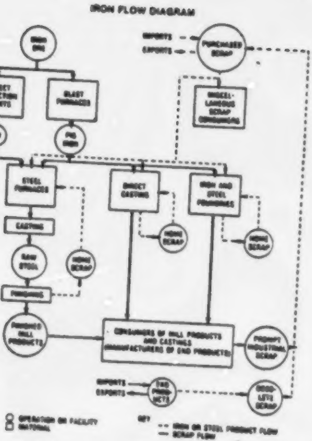

Figure 1.—Iron material flow diagram.

In recent years, the size, productivity, and efficiency of blast furnaces have greatly increased. The largest modern blast furnaces have working volumes 2.5 times that of furnaces constructed in the 1940's, and productivity per unit of working volume has increased by improved charge quality and preparation, including use of sized ore, pellets and sinter, better fuel and refractories, higher blast temperatures and volumes, humidity control, fuel and oxygen injection, and high top pressure.

Direct-reduced iron, also known as prereduced iron or sponge iron, is produced by several processes by which iron ore or pellets are reduced to solid iron by reductants produced from solid, liquid, or gaseous fuels. For steelmaking, direct-reduced iron should not contain more than a small percentage of the slag-forming materials silica and alumina (the less the better and preferably no more than 4%). Direct-reduced iron may be in the form of sized lump, briquets, pellets, or unconsolidated fines, depending on the original raw material and the process used to produce it. Normally, it is less than 1 inch in maximum dimension, except for briqueted fines, which may reach 3 inches.

Direct-reduced iron can be used to replace all or part of the purchased pig iron or scrap in cold-melt steelmaking and foundry operations. It is most efficiently used by continuous charging through the electric arc furnace roof during melting, rather than charging in large batches as is done with scrap. Direct-reduced iron is especially valuable for feed to electric arc furnaces making high-grade steel, because it is much lower in the tramp elements normally found in most scrap. Mainly for economic reasons, only a relatively small quantity of direct-reduced iron is used in the United States.

Scrap.—The scrap industry consists of collectors and small dealers, large dealer-processors, and brokers. Collectors and small dealers generally handle all types of waste, and the large dealers and processors specialize in iron and steel scrap, nonferrous metals, waste paper, etc. Processors of scrap employ a large variety of equipment. Shears of various types are used for cutting bulk scrap and flattened automobile bodies to manageable size. Balers are hydraulic presses capable of compressing an automobile body or other light scrap into a dense cube. One modern development is the shredder or fragmentizer, which is capable of reducing an automobile to fist-size pieces of scrap in less than 1 minute. The iron and steel fraction is magnetically separated from the other materials to produce high-quality scrap. Shredders, depending on their size, can process from 25,000 to 250,000 cars per year.

Another development is the mobile car crusher, which flattens cars prior to shipment to the scrap yard, and makes possible the more economic transportation of scrapped automobiles over greater distances.

Other processing equipment includes the cutting torch, the drop ball for breaking cast iron scrap, the rail breaker, and the briquetter and turnings crusher for compacting turnings and borings.

Materials handling equipment includes belt conveyors and overhead and crawler cranes equipped with electromagnets or grapples.

Steelmaking.—All contemporary steelmaking processes convert pig iron, scrap, or direct-reduced iron, or mixtures of these, into steel by a refining process that lowers the carbon and silicon content and removes impurities, mainly phosphorus and sulfur. The excess oxygen remaining in the molten steel is then neutralized by adding deoxidizing elements such as manganese, silicon, or aluminum.

The first commercially developed process for producing steel in tonnage quantities was the Bessemer process in which air is blown through a bath of molten pig iron in a pear-shaped converter. Because the acid Bessemer process produced steel with a high nitrogen content, was unable to utilize much scrap, and was unable to remove phosphorus, it was gradually replaced by the basic open-hearth process in the United States. The Thomas process, which utilizes a basic-lined converter, is still used to a small extent outside the United States.

The basic open-hearth process was the dominant steelmaking method in the United States between 1908 and 1969. In this process, a relatively shallow bath of metal is heated by a flame that passes over the bath from burners at one end of the furnace, while the hot gases resulting from combustion are used to heat checker-brick regenerators at the other end of the furnace. Periodically, the direction of the flame is reversed, the hot checker-bricks preheating the air for combustion, and the exhaust gases reheating the checkers at the other end of the furnace; gas, oil, or tar can be used as fuel.

The electric arc furnace has been used since its inception at the beginning of the century for the production of stainless and alloy steels, including tool steels. Since about the end of World War II, it has been increasingly used for the tonnage production of plain carbon steels. In almost all cases, the electric arc furnaces operate with a cold charge in which the ferrous content is close to 100% scrap. Direct-reduced iron is a potential substitute for scrap, and it is used as the major iron input in some electric arc furnace plants.

Close control of quality can be obtained in the basic electric arc furnace, and sulfur can be removed using special slags. One advantage of the electric arc furnace process is its relatively low capital cost per ton of steel produced. Plants can be located to take advantage of local supplies of scrap, and local markets for steel. Small electric arc furnace plants have been built in locations where large integrated steel mills would be uneconomical in many parts of the United States, in Europe, especially in Italy and Spain, in Japan, and in the developing countries.

In making stainless steel in the electric arc furnace, oxygen lancing has long been used to reduce the carbon to the required low level. Processes have been developed in which the metal is first melted in the electric arc furnace and refined in a second vessel, using combinations of oxygen with argon, vacuum, or steam for decarburization. Almost all stainless steel is now produced in the United States by the argon-oxygen-decarburization (AOD) process. The AOD process is able to remove carbon from molten steel without oxidizing large amounts of valuable alloying elements, especially chromium. The process economically produces stainless steel using lower grade, lower cost, high-carbon ferrochromium instead of refined low-carbon ferrochromium.

Other developments in electric arc furnace melting include the use of ultrahigh power, that is, operation at about twice the power rating formerly used for a given size furnace, which reduces the melting time by about one-half. These high-power levels have stimulated development of high conductivity graphite electrodes, coatings of electrodes to reduce oxidation losses, water-cooled power cables, water-cooled furnace panels and roofs, and improved refractories.

The electric induction furnace differs from the electric arc furnace in that the metal is heated by induced electric current within the charge rather than by an arc. Induction furnaces are generally smaller than electric arc furnaces, and often they are used in iron and steel foundries and for special purposes such as melting under vacuum or in an inert atmosphere, and melting of relatively high-purity charge materials.

The latest entry into the steelmaking process is the basic oxygen process (BOP), which was developed in Austria as the Linz-Donawitz (L-D) process. Beginning in the early 1950's in the United States, it is now the dominant steelmaking process in this country. In this process, a jet of pure oxygen is injected into the molten metal by a lance of regulated height in a basic refractory-lined converter. Excess carbon, silicon, and other reactive elements are oxidized during the controlled blows, and fluxes are added to form a slag. A production cycle can be completed in approximately 45 minutes. Under present practice, the charge consists of about 28% scrap with the balance molten pig iron.

Several variations on the standard BOP have been developed. In various processes, oxygen, fuels, lime, or inert gases may be injected through tuyeres in the sides or bottom of the furnace vessel, with or without the use of the top lance.

Consumable electrode remelting processes are used to produce high-quality steel for special purposes. The processes include vacuum-arc remelting and electroslag remelting. Elimination of ingot segregation and better ingot surface, density, and yield are among the advantages. The processes consist of remelting electrodes of the steel to be refined by an arc under a vacuum or controlled atmosphere or a slag cover.

Additive Elements in Steel.—Several elements may be added to molten steel to remove dissolved oxygen (deoxidation), to control the embrittling effects of sulfur, or to change the properties of the finished steel. The main functions of the more common additive elements are shown in table 2. Hardenability is a measure of the depth of hardening of a steel and it is useful in steels that are to be heat treated. High-temperture hardness and strength are useful in cutting tools and in high-temperture applications.

Casting.—After the steel has been refined in the open-hearth, basic oxygen, or electric arc furnace, it is transferred to a refractory-lined ladle and poured through a nozzle in the bottom into ingot molds or into a continuous-casting machine. Ingot molds are tall cast iron containers weighing from 1 to 1.5 times as much as the ingots cast in them. The molds are usually tapered to facilitate removal of the ingots, which may range in size from a few hundred pounds for specialty steels to 300 or more tons for large forging ingots. however, most ingots are in the 10- to 40-ton range. The exact shape of the ingot is determined by the products to be made from it.

Table 2.—Additive elements in steel

Element	Function in steel
Aluminum	Deoxidation and grain-size control
Chromium	Hardenability, high-temperature strength, corrosion resistance
Cobalt	High-temperature hardness
Columbium	As-rolled strength
Copper	Corrosion resistance and precipitation hardening
Lead	Machinability
Manganese	Deoxidation, sulfur control, hardenability
Molybdenum	Hardenability, high-temperature hardness, temper brittleness control
Nickel	Hardenability and low-temperature toughness
Rare earths	Inclusion control, ductility, toughness
Silicon	Deoxidation, electric properties
Sulfur	Machinability
Tungsten	High-temperature hardness and hardenability
Vanadium	Grain-size control, hardenability, high-temperature hardness

Casting of steel into continuous strands, which are then cut into blooms, billets, or slabs (terms defined in the section "Rolling and Forging"), has the advantage of producing a higher yield than ingot casting and eliminating the primary hot rolling process. Continous casting of steel on a commercial scale originated in Europe in the early 1950's and was introduced in the United States, generally as large-scale units, during the 1960's. Continuous-casting machines consist basically of a relatively short, water-cooled copper mold; a cooling chamber containing water sprays below the mold; pinch rolls; and rollers for supporting the casting beyond the cooling chamber. The mold generally oscillates vertically to prevent sticking of the casting. When the molten steel comes into contact with the mold, a thin skin of solid metal forms; the center of the casting remains molten until some distance below the bottom of the mold where it is finally solidified by the water sprays in the cooling chamber. The steel from the ladle is poured into a refractory-lined container known as a tundish, from which it flows into the mold through a nozzle in the bottom. The tundish may have two or more nozzles for simultaneous pouring into a multiple-strands machine. There are four basic design in contemporary use: vertical casting, in which the vertical steel strand is torch-cut into slabs or billets, which are then lowered into the horizontal position; the vertical-plus-bending machine, in which the casting is bent into the horizontal position; the semihorizontal, or curved-mold design, which uses a specially designed mold and a curved cooling chamber, which permits the height of the machine to be about one-third that of vertical types; and horizontal casting.

Another process, used to a limited extent, is bottom-pressure pouring of blooms, billets, or slabs in which the molten steel is forced by air pressure into graphite molds, where it solidifies.

Rolling and Forging.—After ingots have been stripped from their molds, they are reheated in soaking pits to bring them to a uniform temperature of 2,150° to 2,450° F prior to rolling in a primary mill. Soaking pits are large furnaces, usually below ground level, heated by oil, gas, or electricity. A primary mill reduces ingots to blooms, billets, or slabs by a process of gradual compression between two rotating rolls driven by a powerful electric motor. Several passes through one of more sets of rolls (stands) are required to reduce an ingot to final size.

Blooms and billets are mostly square in cross section, differing only in size. blooms generally range from 6 to 12 inches square, and billets range from 2 to 5 inches square. Slabs are oblong in cross section, usually ranging from 2 to 9 inches thick and 24 to 60 inches wide, although thicker and wider slabs may be produced. These products, whether rolled from ingots or continuously cast, are known as semifinished steel.

IRON AND STEEL

Ends of the still-hot products from primary rolling or continuous casting are cropped to removed defective material. Blooms, billets, or slabs may be continuously rolled further in one operation to intermediate or finished products; however, they are usually cooled and stored. Before the next processing step, most material is surface conditioned to remove defects by grinding or by scarfing with an oxygen torch.

Reheated semifinished steel is processed either into flat-rolled products or into rails, structural or other shapes, bars, wire rods, pipe, or tubing. Flat-rolled products are produced on smooth-faced rolls in contrast to grooved rolls used to make the other products. Flat-rolled products include plate, sheet, strip, tinplate and blackplate, and other products such as skelp, which is used to make welded pipe. Blackplate, a term remaining from blacksmith days, is thin, cold-rolled sheet steel used mainly to make tinplate. About one-half of all steel rolled in the United States is flat rolled. Sheet, strip, blackplate, and tinplate comprise about three-fourths of all flat-rolled material. Hot-rolled bands are intermediate products, obtained by hot rolling an ingot, slab, or billet until its thickness has been reduced to 1/8 to 1/4 inch, and are further processed by cold rolling.

Sheet and strip differ only in width and thickness and are both produced on continuous hot strip mills. Hot-rolled carbon steel strip ranges up to 12 inches wide and may be thinner than sheet, whereas sheet is over 12 inches wide.

A continous hot strip mill consists of one or more sets, or stands, of roughing mills and a final series of finishing rolls. Finishing rolls are four-high, that is they consist of four rolls arranged vertically, with one pair of smaller work rolls that deform the steel and one pair of larger backup rolls that prevent excess deflection of the work rolls. Hot rolling usually begins at 2,200° F and finishes well above 1,300° F. The product of the hot strip mill may either be used without further rolling, or further processed by cold rolling.

If sheet or strip is to be processed further, it is necessary to remove the oxide coating, or mill scale, from the surface. In most cases, this is done by pickling, that is, chemically removing the scale with a solution of hydrochloric or sulfuric acid. In some cases, shot or grit blasting is used to remove the scale. After descaling, the steel is coated lightly with oil to prevent rusting. Most hot-rolled material is given a light cold pass through temper-rolls, to improve flatness, surface quality, and mechanical properties. The product is usually coiled; if cut into sheets, it is usually flattened or leveled. Coiled material may be slit into narrower widths on a slitting line and recoiled.

Plate is flat-rolled product heavier than sheet. Plates up to 48 inches wide have a minimum thickness of 0.23 inch; with plates over 48 inches wide, the minimum thickness is 0.18 inch. Plate is used for fabricated structures such as bridges, storage tanks, pressure vessels, railway cars, and ships.

Railroad rails, structural and other shapes, bars, and rods are rolled on grooved rolls in several passes, the final pass being through grooves having the dimensions of the finished product. Structural shapes include I-beams, angles, channels, and wide-flange beams. Other shapes include miscellaneous sections for special purpose. Bars may be round, square, or hexagonal in cross section.

Wire rod, which is also hot rolled on grooved rolls, is the starting material for wire drawing. Seamless tubing is rolled on special mills equipped with piercing mandrels for forming the inside bore.

Forging is a form of hot working that may be done by hammering or pressing, usually with a die for controlling shape. Hammers are operated by steam, compressed air, or electromechanical devices; presses are either hydraulic or mechanical.

Extrusion is a related hot-working process. A machine-driven ram shapes metal confined within a tubular container by pushing the metal out through a die opening at the opposite end of the container.

Cold Rolling.—In cold rolling, the only heating the metal receives is a small amount from frictional effects during deformation. Cold-rolled steel is stronger and has better surface and dimensional characteristics than hot-rolled steel. Most cold rolling is done continuously, semifinished steel (hot-rolled bands) being fed through rolls from a coil.

Steel is most frequently cold rolled in four-high mills in which each work roll is backed by a larger roll with all rolls being vertically aligned. In a continuous-tandem mill, three to six such four-high roll stands are arranged in a line. Material from a coil is reduced progressively as it advances through each stand. Some steel is rolled using single-stand, four-high reversing mills; the steel is rolled first in one direction and then in the reverse direction until the final gage is reached. Another type of mill used for special applications is the Sendzimir mill, which has a clustered arrangement of backup rolls for transmitting force to the work rolls. In addition to roll stands, a typical cold mill may also have other equipment or lines for intermediate annealing and cleaning of steel. Some form of heat-treatment is applied to most cold-rolled sheet or strip to restore the ductility lost in cold reduction, except when it is desired to take advantage of the improved strength developed in cold rolling.

Coatings for Steel.—Protective coatings have been developed for steel to prevent it from rusting and corroding and to expand its use. These coatings include, singly or in combination, other metals such as aluminum, chromium, nickel, lead, tin, and zinc, vitreous enamel, organic paints, varnishes, enamels, lacquers, and plastics. Most important of the metallic coatings for flat-rolled steel are zinc, tin, and chromium. In 1983, 9.5% of all steel shipped was galvanized, 4.4% was tinplate, and 1.4% was tin-free steel electroplated with chromium.

Continuous hot-dip galvanizing, a method developed in the mid-1930's, is used in about 90% of galvanized steel production. In this method, a prepared coil of either hot-or cold-rolled steel is passed through a molten zinc bath. Relatively thick coatings of about one-thousandth of an inch are produced. An increasing amount of galvanized steel is being produced by the electrolytic deposition of zinc. Electrolytic galvanizing can produce thinner coatings and better surface finishes, and can coat types of steel that would be harmed by the heat of hot-dip galvanizing. Galvanized steel is used in the automotive and construction industries, and in a wide range of other applications. Recently developed zinc-aluminum alloy coatings compete with conventional galvanized steel. An operation similar to galvanizing is used to manufacture long terne sheet, which is steel coated with a lead-tin alloy. Long terne sheet is a small tonnage item especially suited for gasoline tanks.

Tin cans are made from tinplate, which is produced by a continous process of electrolytic deposition of a tin layer onto cold-rolled sheet steel. Subsequent heating of the as-plated steel fuses the coating and gives it a metallic luster. Thickness of the tin layer amounts to only tens of a millionth of an inch. Electrolytic tinplate manufacture began superseding hot dipping in the United States in 1937.

Production of tinplate has declined somewhat in recent years, partly because of competition from aluminum cans and partly because of the development of tin-free steel, which is made from the same steel as tinplate, but coated instead with chromium. The coating is thinner than tin coatings, it is put on electrolytically, and it is lacquered to make it suitable for certain food and beverage containers.

APPENDIX

ADDITIONAL MATERIALS SUBMITTED FOR THE RECORD

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

VOLUME 2

SOLAR AND OTHER RENEWABLES

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Renewable Energy

PRINCIPAL RENEWABLE ENERGY ISSUES

Renewable energy based sources--solar, biofuels,wind, ocean, hydropower, and geothermal--presently account for about 8 percent of the energy consumed in the United States in 1984. In certain locations, the contribution of specific renewable energy technologies is even greater, e.g., 15 percent of all water heaters in Hawaii are solar, 8 percent of California's new electric generation capacity is renewable. As the various renewable energy technologies continue to develop, their economic and technological viability should improve and their collective contribution to the Nation's energy needs should continue to increase. Availability of this source of energy is thus a major element of national energy policy.

DOE's Renewable Energy Programs

DOE's renewable energy programs include a number of technology areas of potential importance to the nation's energy production, storage, and distribution network:

- Solar Buildings technology addresses the R&D associated with both active and passive solar heating and cooling, active domestic hot water heating, and passive daylighting.
- Photovoltaic technology converts sunlight directly into electricity through use of solid state electronic devices.
- Solar Thermal technologies focus sunlight on a receiver to produce electricity, heat, fuels, or chemicals.
- Biofuels technologies include the production of biomass feedstocks and the conversion of these and municipal waste into fuels.
- Wind energy technology employs a variety of technical concepts, including vertical axis turbines, horizontal axis turbines, augmenters, and contained systems.
- Ocean energy technologies use the thermal or kinetic energy stored in the oceans to produce electricity.
- Geothermal technology converts heat stored in geologic formations into useful energy. Four types of geothermal resources-- hydrothermal, geopressured, hot dry rock, and magma--are combined with several conversion technologies to produce useful energy as heat or electricity.
- Hydropower is the conversion of the kinetic energy of flowing water into mechanical or electrical energy.
- Electric energy systems supports research directed toward solving mid- to long-term problems in electric transmission and distribution, and incorporating new concepts and renewable energy resources into the utility network.

- Energy Storage supports advanced energy storage and electrochemical systems to facilitate the substitution of oil and gas fuels by coal, nuclear or renewable energy sources.

In 1974, when the federally supported renewable energy program began, most of these technologies were either in the conceptual stage or existed in rather primitive forms. Only solar water heaters, combustion of biomass materials and biogas digesters were in appreciable use in a few countries. Photovoltaic systems were used in space. Small wind machines to pump water and provide remote electrical output were commonplace in the early 1900's but had virtually disappeared the 1970's. Only a few dry steam geothermal plants were in commercial operation. Us of woody biomass for the production of process heat and electricity especially in woo processing industries was well established. The only noteworthy ocean energy systems were small wave-power generators used for navigational buoys. Electric systems were small with only limited interregional interconnections, and only a few systems were equiped with any automated equipments for dispatching and management. Storage was conceptually defined but economics and reliability prevented its application.

During the past decade major advances have been made in all of the renewable energy technologies. New materials have been developed with the thermal, optical, and physical properties required for lower cost and higher performance. New components have been tested and substituted for less effective ones. Extensive systems analysis has been performed and hundreds of systems have been studied under both controlled laboratory conditions and typical field operation conditions. Teams of scientists and engineers in Government laboratories, universities, and industry have created a solid technology base and expertise in the extremely broad array of disciplines pertaining to renewable energy technologies.

The DOE estimates that renewable energy provided more than 8 percent of the primary energy consumed by the United States in 1982, primarily from direct combustion of wood, geothermal power, and hydropower. Renewable energy also represents more than 9 percent of indigenous energy production. The contribution of newer renewable energy technologies is more difficult to assess because their history in the marketplace is brief and statistically not yet significant. However, several indicators suggest that these technologies are already being recognized:

- Photovoltaic shipments increased from 2.5 MW in 1980 to over 12 MW--industry revenues are approximately $150 million.

- Small-to medium-scale wind turbines with total capacity of approximately 1,000 MW has been installed as of 1985.

- Some 800,000 to 1 million active water heating systems have been installed as of 1985.

- Geothermal electric systems provide in excess of 2,000 MWe and geothermal direct heating applications provide 60 trillion Btu per year as of 1985.

- Small-scale hydropower plants provide approximately 6,200 MWe from 1,153 plants.

- Direct combustion of wood currently contributes over 2.6 quads per year.

- Facilities for converting municipal waste to heat and electricity have risen from 7 in 1974 to 60 in 1985.

DOE projects that 13 percent of total energy consumption could be derived from renewable sources in 2010. Wood, geothermal, and hydropower are expected to provide most of this energy through the midterm, but newer technologies (e.g., photovoltaics, wind, solar building technologies, solar thermal power, advanced biofuels) should become significant at the national level during the 1990's. As renewable energy and other small scale or intermittent energy supply technologies become more prevalent, additional storage and control technologies will be required particularly as they relate to efficient and reliable management of the nation's electric energy system.

RENEWABLE ENERGY FRAMEWORK

Within the context of the National Energy Policy Plan, renewable energy sources can make a significant contribution to national energy needs. Renewable energy sources can complement conventional energy sources and can, through their diversity, reduce the impact of sudden energy supply interruptions or price increases in any single energy source. Renewable energy resources, where designed and constructed with appropriate storage and supply system interconnection technologies, can offer the flexibility of direct matching of various energy requirements with locally-available energy sources. The modularity of renewable energy equipment allows additions to be made in comparatively small increments, resulting in short lead time, reduced planning uncertainties, and comparatively small capital outlays. In rapidly changing and uncertain energy markets, this modularity offers significant economic benefits to energy producers and consumers.

A number of renewable energy technologies capable of providing these advantages are not yet a significant factor in the energy market. Additional R&D is required to accomplish and confirm the competitive viability of a number of these concepts while maintaining the integrity and safety of the nation's supply network. Long-term cost and demand projections indicate that many of these options represent attractive energy supply alternatives; however, the short-term outlook tends to discourage renewable energy investment by industry. Accordingly, continued Federal investment in renewable energy R&D appears prudent to ensure that a reasonable number of renewable energy supply options are available to the private sector in the long term. Additional factors influencing Federal investment in renewable energy R&D include:

- Early research breakthroughs often show enormous promise several years down the road. However, industry is frequently unable or unwilling to invest for an unknown or inadequately defined commodity. This is true of several renewable energy concepts where, despite remarkable initial success, a substantial amount of technical progress is still required before informed business decisions can be made regarding the individual technology options.

- The private sector frequently operates under a different set of decision criteria than does Government. One measure of this difference is in the time value of money used by industry and by Government. Heavy discounting typically employed in industrial decision making greatly reduces the value of long-term benefits relative to short-term results. Industry also views energy as just one input in the production process. Thus, industry will frequently reject investments unless they clearly offer nearer-term profits. Federal R&D investments may be justified in certain instances to encourage longer-term productivity and national returns.

- Individual private companies are rarely able to capture the full economic benefits of an investment in basic science or technology. Other companies often rapidly adopt a successful innovation and limit the company making the original R&D expenditure to a small share of the total market. This limits the willingness of individual companies to invest in certain types of long-term R&D. In the case of the technology options within this budget category, most may follow one of several possible technology development paths. Industrial investment often focuses on a single path in an area of proprietary interest that builds upon more generic investigations addressing broader areas of concern.

PROGRAM OBJECTIVES

The renewable energy budget category entails a broad variety of energy production, storage and distribution management technology which varies considerably with respect to verification of basic concepts and competitive viability. As a general rule federal funding is concentrated in basic and applied research and development which is conducive to informed decision making by the private sector regarding the development of a reasonably broad range of potentially competitive technology. Federal attention is concentrated on scientific and engineering research necessary to accomplish a better understanding of basic resource and technology phenomena, methods to employ these resources for producing competitive and useful forms of energy and important crosscutting technologies for storage of energy and for reliable and efficient management of the electric energy supply network.

Within this context, specific technology development objectives have been developed in collaboration with industry to ensure that federally funded research does not supplant research investments by the private sector and that federal investments are focussed on investigations most critical to advancing promising technology options towards confirmed competitive viability. Technology specific objectives vary somewhat according to the nature of the fundamental issues being addressed and the comparative definition of the technology involved. Guiding objectives for the federal effort therefore range from basic materials related issues such as the structural integrity of reflective surfaces or conversion efficiency of various photovoltaic or electrochemical storage materials; to resolution of wind technology reliability and durability issues through advancement of underlying structural and aerodynamic theory; to resolution of environmental uncertainty attendant to combustion of municipal wastes.

PROGRAM GUIDELINES

DOE has developed a generalized framework to uniformly assess multiyear applied research activities within each renewable energy technology.

The diversity of renewable energy technologies and the many storage and control mechanisms required for their incorporation into the energy supply network makes a uniform assessment of research and development programs extremely complex. While all renewable energy technologies ultimately depend on a renewable, frequently intermittent, energy resource such as wind or sunlight, a variety of conversion options (e.g., solar thermal systems, binary cycle geothermal) can produce one or more useful energy types, for example, electricity, fuel, and thermal energy which may be interfaced with various types of energy distribution and utilization networks.

As an example of the complexity of renewables, the various biofuels conversion options can collectively convert a wide range of organic matter into electricity, bulk solid, liquid or gaseous fuels, or direct thermal energy. However, the degree of current or potential viability of each option will vary regionally because of resource availability, technology performance, and regional demand profiles.

The varying degree of technical maturity of each option is a second source of analytical complexity. For example, some options, such as power generation using magma as a geothermal energy source, are still theoretical concepts. For this option, extensive research is required to determine the feasibility of using this energy source for power generation. Others, such as hydrothermal dry steam, represent commercial or near-commercial options, subject to only limited improvements through R&D advances.

Industry structure and maturity is a third important source of complexity. For example, in some instances an identifiable industry has established at least an initial market presence such as in solar water heating, and has developed the institutional and financial infrastructure to fund development and manufacturing. In other instances, no identifiable industry exists, as in the case of magma power, or an industry (such as electric utilities) exists but the capital and reliability constraints imposed on it tend to discourage adoption of innovative and risky technologies.

This complexity dictates an evaluation method that explicitly considers the unique aspects of each technology option, while maintaining consistency across all renewable energy technologies. The levels of Federal support requested for the various renewable energy technologies are based upon the results of this type of evaluation. This FY 1987 budget reflects a sound and stable commitment to the continuing development of these technologies. This proposal will increase understanding of the potential for virtually all of the most promising solar energy options and will substantially contribute to the base of technical information required for informed decisionmaking by the public and private sectors.

One of the primary goals of all the applied research areas in Renewable Energy is to effectively transfer technology from Federal and university laboratories to private industry. The earlier industry is involved, and the more directly that the research agenda is guided by the companies' own economic self-interest, the more effective the transfer is likely to be. A funding approach will be explored in 1987 as an effort to increase the private leverage of Federal funds, provide industry with increased involvement in the choice of technology development directions, and help limited Federal funds to support emerging industry more broadly. This approach is to solicit industry interest in joining together to form cooperative R&D ventures within broad sectors of the economy. This ultimately could transform most or all of the industry-performed work in Renewable Energy, and can facilitate transfer of advanced technology to the private sector. Many areas of industry-performed Renewables R&D work offer opportunities for this approach.
Cooperative ventures are potentially suited to this technology-transfer/proof-of-concept stage of activity. By law, and because of the competitive interests of the companies involved, their activity is restricted to precompetitive (i.e., not product-specific) research and development. The cooperative ventures would be designed to meet this criterion. This matches Administration policy of supporting longer-term generic research that benefits the public, but not using tax dollars to subsidize a particular company's development of proprietary products. Support of industry-cooperative R&D allows limited Federal funds to strengthen a whole industry and not just one or a few selected players. This could benefit emerging industries as well as more mature ones.

The voluntary organization of such cooperative ventures by industry would serve as a strong indicator for the proper direction of government-sponsored R&D. The pooled funding will also provide a greater degree of private cost-sharing for applied R&D, allowing Federal dollars to go farther.

If the cooperative venture is defined broadly, with a substantial membership base and level of funding, it can perform or sponsor technology development projects in a number of related areas. This serves to further reduce the risk to the participants, ensuring better chances for shared successes that will repay each party's investment.

The Department will not place tight constraints on the types of cooperative opportunities to be considered, but key characteristics of the concept include:

- Significant leveraging of Federal funding;
- The support that the Department would provide should not displace support that would otherwise come from the private sector;
- The Federal government will share in royalties or other repayment profits from the venture, proportionate to its contribution to the venture;
- Participation of two or more companies;
- Preferably ventures should include companies that have previously proven themselves successful in obtaining and managing co-funding from private sources.

As industry develops responses to this opportunity, the Department will consider reprogramming of monies to allow participation in promising cooperative ventures.

RENEWABLE ENERGY PROGRAM BUDGET

The levels of federal support in the budget for the various renewable energy, energy storage and electric energy systems technologies are considered appropriate given the appropriate Federal role and the need to progressively reduce federal budget deficits in light of the comparative needs and levels of federal funding for various other governmental activities. These levels of investment will provide for continuing progress in completing development of the technology base required for industrial decision making regarding these promising energy supply and management technologies.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW

SOLAR ENERGY

The solar programs support research and development that will strengthen the technology base from which industry can draw in developing future new products and processes for commercial market development. The programs support activities ranging from basic research in universities and National Laboratories to applied R&D and proof-of-concept projects by the industrial sector. The FY 1987 budget request for Solar Energy is $72,292,000 which is a $72,332,000 reduction from the FY 1986 adjusted appropriation of $144,624,000.

Reductions in the Renewable Energy R&D programs are proposed in the 1987 Budget consistent with budgetary constraints. In addition, a new innovative cooperative R&D approach will be carefully reviewed and expressions of interest will be solicited from industry. Partnerships with industry-formed cooperative R&D ventures to support longer-term high-risk applied technology development of generic or precompetitive nature, may be an effective method to leverage Federal monies and increase program impact. This approach is intended to promote more effective technology transfer and to allow broader research support within current fiscal constraints.

The 1987 solar energy program will support generic and long-range research in a wide variety of alternative energy technologies, structured to provide a sound base from which industry can draw particular applications. The major areas being investigated, as in past years, are moderate and high-temperature solar heat, photovoltaics, biofuels, wind, ocean thermal energy conversion, and solar building technologies. The main research topics being pursued at universities and national laboratories within these application areas are materials sciences, aerodynamic/ fluid-dynamic modeling, biomass production and conversion technologies component system research, and thermodynamic cycles. Industry will be involved in applied research in these areas. In addition, funds are provided for technology transfer and international cooperative activities, generic resource assessments, and capital improvements at the Solar Energy Research Institute.

Prior Year and Recent Accomplishments

Solar Building Energy Systems

- Completed construction and testing of full-scale thin film polymer collectors with copper alloy absorbers and will complete evaluation and transfer of results to industry.

- Completed testing of the double-effect (2R) regenerative absorption chiller in the cooling mode and performed detailed analysis of the single-effect (1R) regenerative absorption cycle and will fabricate the 1R chiller.

- Completed testing of the heat pipe version of the Integrated Stationary Evacuated Concentrator (ISEC) collector and completed side-by-side testing of the new North-South oriented CPC collector.
- Completed testing of the half-scale parallel passage solid desiccant dehumidifier in the specially constructed test facility and completed testing of an advanced solid desiccant material.
- Completed a single family residential building design handbook for passive cooling load avoidance based upon ventilation and shading strategies.
- Completed the nonresidential passive solar experimental buildings program which shows passive systems supplying one-third to one-half the energy requirements at no additional cost.
- Provided design practitioners with a practical solution for daylighting single story nonresidential buildings.
- Developed multi-layered electrochromic optical switching materials for smart windows that control solar heat gains and losses.
- Completed encapsulation of new phase change thermal storage materials in conventional building materials thereby tripling their capacity for charging and discharging solar heat gain.
- Developed new low-conductance glazing materials and coatings which minimize window heat losses.
- Developed new holographic window films and light guides for enhanced daylighting deep in building interiors.

Photovoltaic Energy Systems

- Achieved 8% total area efficiency for an amorphous silicon submodule having an area of 1000 cm2 and an 11% efficient amorphous silicon solar cell.
- Achieved the growth of single crystal GaP on Si for a monolithic concentrator cell device.
- Developed a direct patterning process for solar cell contacts using laser beam surface activation. Electrolytic plating of silver onto the pattern completes the metalization system.
- Produced 50,000 cm2 of dendritic web silicon ribbon in one furnace in a growth cycle less than one weeks's time. At this point web ribbon will have an economic advantage over ingot and slicing technology.
- Developed and verified an analytical solar cell simulation model which correlates with experimetnal data to within 3%.
- Achieved a 26% efficient GaAs concentrator cell, a 25% efficient GaAs/SI stacked concentrator solar cell and a 20% efficient GaAs concentrator mini-module.

Solar Thermal Energy Systems

- Performed testing of a three meter diameter stretched membrane concentrator to establish membrane to frame coupling.
- Completed the first two years of the three year power production phase at Solar One.
- Completed molten salt component and subsystem experiments at the Central Receiver Test Facility in Albuquerque, New Mexico.
- Completed data evaluation of the first year of utility ownership and operation of the Shenandoah Solar Total Energy Project.
- Completed evaluation of the parabolic dish module and initiated construction of the Small Community Solar Experiment at Osage City, Kansas.
- Completed evaluation of the parabolic dish module selected for the second Small Community Solar Experiment at Molokai, Hawaii.
- Completed the comparison of solar thermal systems for electric power production.
- Concluded the hemispherical bowl project at Crosbyton, Texas.
- Completed the study of conversion options for Solar One and transmitted the report to the Congress.
- Initiated the transfer and consolidation of the central receiver systems program from Sandia National Laboratories-Livermore to the Sandia Laboratories-Albuquerque.
- Completed the first phase of the Innovative Concentrator contracts and initiated final design, fabrication and evaluation activities.
- Initiated cooperative management and research on Free Piston Stirling Engines with NASA/Lewis Research Center.
- Completed laboratory evaluations of thermochemical reactions and initiated tests of the most promising concepts for energy transport at the Distributed Receiver Test Facility in Albuquerque, New Mexico.
- Terminated support of Brayton cycle engines as not being capable of achieving near and long term program goals.
- Completed operations and maintenance evaluation of the Vanguard parabolic dish module (Advanco concentrator/United Stirling engine) at Rancho Mirage, California.

Biofuels Energy Systems

- Completed successful shakedown operations for 3000 kW combustor/gas turbine generator.

- Conducted full-scale combustion in an operating test facility to enhance MSW combustion efficiency and reduce emissions.
- Conducted laboratory testing of enzymatic hydrolysis to verify parametric analysis.
- Identified candidate short rotation woody species capable of genetic improvements in order to increase average yields of as much as 40 percent.
- Compared first growth yields with regrowth yields of short rotation woody species to document that regrowth yields are 20-100 percent higher.
- Analyzed the formation of trace organic substances (dioxins) during thermal conversion of municipal solid waste (MSW).

Wind Energy Systems

- Developed improved aerodynamic and structural codes to incorporate dynamic stall, turbulence and other unstead phenomena.
- Developed theories to predict effects of small-scale turbulence and initiate field tests investigation of innovative approaches to characterize it.
- Initiated testing of improved airfoils for intermediate size (200 to 600 kW) wind turbines.
- Completed design of 3.2 MW Mod-5 wind turbines.
- Completed variable speed operational testing on Mod-0 and transferred results to industry.
- Initiated a statistical data base on wind turbine fatigue, based with data from cooperative program and test turbines.
- Began design study for advanced horizontal axis test facility to replace the outdated Mod-0.

Ocean Energy Systems

- Completed design and procurement of the vacuum chamber for open-cycle seawater experiments and turbine test article conceptually defined.
- Completed data analysis and evaluation of the 1/3 scale down-the-slope cold water pipe (CWP) tests in Hawaii and developed 2D model to predict CWP loads.
- Completed the modification and test of a pneumatic wave energy conversion machine and initial studies on latent heat OTEC processes.
- Evaluated OTEC mixed effluent discharges using physical model.
- Performed open cycle direct-contact heat and mass transfer experiments.
- Completed detail design of the Seacoast Test Facility upgrade project.

Solar Technology Transfer

- Coordinated arrangements for referral of public inquiries to information and assistance services, including specific notices regarding the scope of responses provided by the DOE Conservation and Renewable Energy Inquiry and Referral Service, the Solar Energy Research Institute and its Technical Inquiry Service, the National Appropriate Technology Assistance Service, DOE's Technical Information Center, and the EIA National Energy Information Center.
- Coordinated the private publication of two books from the Solar Technical Information Program.
- Responded to approximately 40-50,000 public inquiries in FY 1985 on how to use energy conservation and renewable energy techniques.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE

Solar Energy
Energy Supply Research and Development
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Approp.	FY 1986 Approp. Adjusted	FY 1987 Base	FY 1987 Request	Request vs Base
Solar Energy					
Solar Buildings Energy Systems					
Operating Expenses	$8,985	$7,700	$7,700	$4,700	$-3,000
Capital Equipment	200	481	481	0	-481
Subtotal Solar Buildings......	9,185	8,181	8,181	4,700	-3,481
Photovoltaic Energy Systems					
Operating Expenses	45,169	39,523	39,523	19,600	-19,923
Capital Equipment	1,000	1,155	1,155	1,000	-155
Construction	8,480	0	0	0	0
Subtotal Photovoltaic.........	54,649	40,678	40,678	20,600	-20,078
Solar Thermal Energy Systems					
Operating Expenses	33,395	25,596	25,596	15,300	-10,296
Capital Equipment	500	289	289	0	- 289
Subtotal Solar Thermal........	33,895	25,885	25,885	15,300	-10,585
Biofuels Energy Systems					
Operating Expenses	29,031	26,749	26,749	11,600	-15,149
Capital Equipment	1,000	577	577	600	23
Subtotal Biofuels............	30,031	27,326	27,326	12,200	-15,126
Wind Energy Systems					
Operating Expenses	28,155	24,055	24,055	8,080	-15,975
Capital Equipment	200	770	770	170	- 600
Subtotal Wind................	28,355	24,825	24,825	8,250	-16,575
Ocean Energy Systems					
Operating Expenses	4,008	4,811	4,811	2,500	- 2,311
Subtotal Ocean................	4,008	4,811	4,811	2,500	- 2,311
International Solar Energy Program					
Operating Expenses	500	962	962	500	- 462
Subtotal International.........	500	962	962	500	- 462

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
Solar Energy

	FY 1985 Approp.	FY 1986 Approp. Adjusted	FY 1987 Base	FY 1987 Request	Request vs Base
Solar Technology Transfer					
Operating Expenses	5,100	2,983	2,983	1,950	-1,033
Capital Equipment	0	0	0	50	50
Subtotal Tech. Transfer........	5,100	2,983	2,983	2,000	- 983
Solar Energy Research Institute					
Capital Equipment	0	251	251	315	64
Construction	0	1,993	1,993	230	-1,763
Subtotal SERI..................	0	2,244	2,244	545	-1,699
Program Support					
Operating Expenses	1,000	1,251	1,251	897	- 354
Subtotal Program Support......	1,000	1,251	1,251	897	- 354
Resource Assessment					
Operating Expenses	0	914	914	700	- 214
Capital Equipment	0	48	48	0	- 48
Subtotal Resource Assess.......	0	962	962	700	- 262
Program Direction					
Operating Expenses	4,864	4,516	4,516	4,100	- 416
Subtotal Program Direction.....	4,864	4,516	4,516	4,100	- 416
Total					
Operating Expenses............	$160,207	$139,060	$139,060	$69,927	$-69,133
Capital Equipment..............	2,900	3,571	3,571	2,135	-1,436
Construction...................	8,480	1,993	1,993	230	-1,763
Solar Energy.....................	$171,587	$144,624	$144,624	$72,292	$-72,332
Staffing - Total FTE	77	88	88	70	18

Authorizations:
- o P.L. 93-473, Solar Energy Research, Development and Demonstration Act
- o P.L. 93-577, Non-Nuclear Energy Research and Development and Demonstration Act
- o P.L. 95-390, Solar Photovoltaic Energy Research, Development and Demonstration Act
- o P.L. 95-911, Department of Energy Organization Act
- o P.L. 96-294, Energy Security Act
- o P.L. 96-310, Ocean Thermal Conversion Research, Development and Demonstration Act
- o P.L. 96-345, Wind Energy Systems Act

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriaitons

Solar Energy (CE)	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	FTE General Reduction	Gramm-Rudman-Hollings Reduction	Subtotal	Comparability Adjustments	Adj. Approp. Total
Solar Buildings Energy Systems									
Operating Expenses	$ 8,000	$ ---	$ ---	$ -163	$ ---	$ -300	$ 7,537	$ 163	$ 7,700
P&CE	500	---	---	---	---	-19	481	---	481
Subtotal..........................	$ 8,500	$ ---	$ ---	$ -163	$ ---	$ -319	$ 8,018	$ 163	$ 8,181
Photovoltaic Energy Systems									
Operating Expenses	$ 47,000	$ ---	$ 6,470	$ ---	$ ---	$-1,007	$ 39,523	$ ---	$ 39,523
P&CE	1,200	---	---	---	---	-45	1,155	---	1,155
Subtotal	$ 49,000	$ ---	$-6,470	$ ---	$ ---	$-1,052	$ 40,678	$ ---	$ 40,678
Solar Thermal Energy Systems									
Operating Expenses	$ 26,600	$ ---	$ ---	$ -123	$ ---	$-1,004	$ 25,473	$ 123	$ 25,596
P&CE	300	---	---	---	---	-11	289	---	289
Subtotal	$ 26,900	$ ---	$ ---	$ -123	$ ---	$-1,015	$ 25,762	$ 123	$ 25,885
Biofuels Energy Systems									
Operating Expenses	$ 27,800	$ ---	$ ---	$ -11	$ ---	$-1,051	$ 26,738	$ 11	$ 26,749
P&CE	600	---	---	---	---	-23	577	---	577
Subtotal	$ 28,400	$ ---	$ ---	$ -11	$ ---	$-1,074	$ 27,315	$ 11	$ 27,326
Wind Energy Systems									
Operating Expenses	$ 25,000	$ ---	$ ---	$ ---	$ ---	$ -945	$ 24,055	$ ---	$ 24,055
P&CE	800	---	---	---	---	-30	770	---	770
Subtotal, Wind	$ 25,800	$ ---	$ ---	$ ---	$ ---	$ -975	$ 24,825	$ ---	$ 24,825
Ocean Energy Systems (OE)	$ 5,000	$ ---	$ ---	$ -37	$ ---	$ -189	$ 4,774	$ 37	$ 4,811
International Solar Program (OE) ..	$ 1,000	$ ---	$ ---	$ ---	$ ---	$ -38	$ 962	$ --	$ 962
Solar Technology Transfer									
Operating Expenses	$ 3,050	$ ---	$ ---	$ ---	$ ---	$ -67	$ 2,983	$ ---	$ 2,983
P&CE	50	---	---	---	---	-50	---	---	---
Subtotal, Solar Technology Transfer (P&CE)	$ 3,100	$ ---	$ ---	$ ---	$ ---	$ -117	$ 2,983	$ ---	$ 2,983
Solar Energy Research Institute (P&CE)	2,332	---	---	---	---	-88	2,244	---	2,244
Program Support (OE)	1,300	---	---	---	---	-49	1,251	---	1,251
Resource Assessment									
Operating Expenses	$ 950	$ ---	$ ---	$ ---	$ ---	$ -36	$ 914	$ ---	$ 914
P&CE	50	---	---	---	---	-2	48	---	48
Subtotal	$ 1,000	$ ---	$ ---	$ ---	$ ---	$ -38	$ 962	$ ---	$ 962
Program Direction	4,900	-161	---	-203	-41	-182	4,313	203	4,516
Subtotal, Solar Energy	$157,232	$ -161	$-6,470	$ -537	$ -41	$-5,936	$144,087	$ 537	$144,624

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriaitons

Solar Energy (CE)	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	FTE General Reduction	Gramm-Rudman-Hollings Reduction	Subtotal	Comparability Adjustments	Adj. Approp. Total
General Reduction (OE)	$ -161	$ 161	$ ---	$ ---	$ ---	$ ---	$ ---	$ ---	$ ---
Management Initiatives (OE)	-6,470	---	6,470	---	---	---	---	---	---
FTE Reduction (OE)	-41	---	---	---	41	---	---	---	---
Pay Restoration (OE)	-537	---	---	537	---	---	---	---	---
Useo of Prior Year Balances (Solar) (OE)	537	---	---	---	---	---	537	-537	---
Total, Solar Energy	$150,560	$ ---	$ ---	$ ---	$ ---	$-5,936	$144,624	$ ---	$144,624
Operating	$144,728	$ ---	$ ---	$ ---	$ ---	$-5,668	$139,060	$ ---	$139,060
P&CE	5,832	---	---	---	---	-268	5,564	---	5,564

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
(In thousands of dollars)

Solar Energy

FY 1986 APPROPRIATION ADJUSTED...............	$144,624
Program increases and decreases	
o Solar Buildings Energy Systems - Overall level of effort reduction in Solar Buildings Energy Systems research and development activities...............	(3,481)
o Photovoltaic Energy Systems - Overall level of effort reduction in Photovoltaic Energy Systems reserach and development activities...............	(20,078)
o Solar Thermal Energy Systems - Overall level of effort reduction in Solar Thermal Energy Systems research and development activities...............	(10,585)
o Biofuel Energy Systems - Overall level of effort reduction in Biofuel Energy Systems research and development activities...............	(15,126)
o Wind Energy Systems - Overall level of effort reduction in Wind Energy Systems research and development activities...............	(16,575)
o Ocean Energy Systems - Overall level of effort reduction in Ocean Energy Systems research and development activities...............	(2,311)
o Solar International - Overall level of effort reduction in Solar International activities...........	(462)
o Solar Technology Transfer - Overall level of effort reduction in Technology Transfer activities...........	(983)
o Solar Energy Research Institute - Overall reduction in plant and equipment for operation of SERI....................	(1,699)

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
(In thousands of dollars)

Solar Energy

o Program Support	
- Overall level of effort reduction in Planning and Analyses	(354)
o Resource Assessment	
- Overall level of effort reduction in Resource Assessment activities	(262)
o Solar Program Direction	
- Reduce FTEs by 18	(416)
FY 1987 Budget Request	$72,292

	FY 86 Adjust. Appropriation	FY 87 Request	Net Change
Solar Buildings Energy Systems..................	$ 8,181,000	$4,700,000	$-3,481,000

The goal of the Solar Buildings Technology program is to advance the engineering and scientific understanding of solar energy, as applied to buildings, and to establish the technology base from which private industry can develop economically competitive solar-related products and designs for use in existing and new buildings. The FY 1987 budget request for Solar Buildings is $4,700,000, which is a $3,481,000 decrease from the FY 1986 adjusted appropriation of $8,181,000.

Research has confirmed that solar energy can be utilized to supply building energy requirements in a large variety of hot water, space heating, cooling and daylighting applications. Conventional building materials and components, as well as energy-related building systems, can be enhanced with improved thermal, chemical, optical and structural properties for the collection, conversion, storage and distribution of energy derived from solar resources. Innovative materials and components can achieve greater control of building heat gains and losses and provide enhanced daylighting at affordable costs and improved durability.

Materials and Components Research

Aperture and building materials research is aimed at improving building apertures to allow control over heat gain or loss. One area of activity aims to prevent heat losses by developing simple, safe and cost effective techniques for creating silica aerogel transparent insulating glazing materials, with minimum light scattering effects. Heat loss through apertures accounts for 25% of the total building heat loss. To control solar heat gain, research will continue towards the development of optical switching films for smart windows which will be durable and cost-effective. Research will continue in the development of holographic gratings which, when applied as film coatings for windows, will redirect daylight over thirty feet into buildings and for developing improved light guide which will transport natural light 50 feet into building interiors.

Thin-film polymer/foil flat plate collectors in the medium temperature range (140^oF-180^oF) for applications in water heating, space heating, and desiccant cooling systems. Research objectives include achieving efficiencies of 50% at 140^oF with very low cost flat plate collectors constructed of thin polymer films and/or metal foils. Funds are requested for the following: (1) analytical and experimental investigations of several candidate ploymers to identify degradation mechanisms resulting from exposure to ultraviolet (UV) radiation, elevated temperatures, and moisture; and (2) evaluation of innovative design alternatives.

Evacuated tube compound parabolic concentrator (CPC) collectors. Research in this area builds upon previous work that resulted in the development of a very high efficiency, high temperature (200°F-400°F) integrated stationary evacuated concentrator collector with potential applicability in solar cooling and industrial process heating systems. Research is planned on advanced designs that incorporate suggested improvements based on design optimization studies. This includes materials research on high optical efficiency absorber coatings (stable up to 800°F), research on alternative absorber designs and heat transfer fluids, and investigations of various fabrication techniques. Experimental testing of candidate designs to verify the achievement of performance objectives (efficiency = 60% at 350°F); and to monitor operational characteristics (e.g., durability) is also included.

Thermal storage materials. Research directed at improving the thermal storage capabilities of conventional building materials will continue with scale-up tests for thermal performance, durability, toxicity, and reliability of materials, including alkyl hydrocarbons and polyalcohols.

Open-cycle absorption systems materials. The open cycle chiller research includes the analysis of several open-cyle system concepts, development of an efficient integral collector/regeneraton prototype, and evaluation of absorption chillers and refrigerant pairs suitable for this application. The operation and experimental evaluation of the prototype system will be undertaken as a part of this research effort.

Systems Research and Development

The Department of Energy has demonstrated that first generation solar buildings can be constructed for essentially the same cost as well designed energy conserving buildings, yet they consume only one-half to two-thirds of the energy. Initially, the program's goal is to extend this knowledge to the four building types that consume 65% of the energy in the nonresidential sector (offices, educational, health care, and retail/wholesale facilities), to multifamily buildings in the residential sector, and to rehabilitation/retrofit applications for all building types. To realize these goals, practical heating, cooling, and daylighting systems must be developed and tested. Research into new heating and cooling technologies and emerging materials and components must be developed, tested and then integrated into optimally functioning systems.

The specific FY 1987 activities that will be conducted are:

Systems research and development (nonresidential buildings). Research directed at providing the buildings industry with practical heating, cooling, and daylighting solutions for nonresidential buildings, in which practitioner confidence is effected through adequate documentation of predictability and proven performance. This would facilitate implementation of these technologies by the buildings industry. The research activities include: (1) Complete development of predictive and analytical tools that describe the energy performance of and occupant response to active heating and cooling systems; (2) Complete development of integrated cooling systems for low/mid rise buildings that utilizes thermal mass in conjunction with ventilative cooling and phase change storage materials; (3) Use validated predictive/analytical tools to develop strategies and controllers that optimally integrate solar building systems; and (4) Continue to monitor, analyze, and evaluate solar buildings systems to determine effectiveness, reliability, and maintainability.

Systems research and development (residential buildings). Research directed at the development of advanced active, passive, and hybrid heating and cooling systems capable of being integrated into the structural systems of multifamily and rehabilitation/retrofit buildings, and guidelines needed to design and integrate these systems with conventional and non-conventional space conditioning systems. This research addresses a need identified by industry for the residential buildings sector, which uses 60% of the energy consumed by buildings. It focuses upon the development of advanced technologies that meet the energy requirements of structurally complex and unique buildings for which existing technologies are inadequate. This research includes: (1) Continued analytical and experimental investigations, of advanced heating and cooling solutions; (2) Experimental analyses of multizone, multistory convective heat and mass transfer, their interaction with HVAC systems, and effect upon occupant comfort; (3) Initial development of guidelines needed to design advanced systems, including hybrid systems and distributed phase change storage materials; (4) Complete development of improved performance prediction and analytical tools; and (5) Continued collection and analysis of system effectiveness data to improve the reliability of solar systems.

Captial Equipment

No new funds are requested for capital equipment.

Photvoltaic Energy Systems

Adjusted FY 1986	FY 1987 Request	Net Change
$40,678,000	$20,600,000	-$20,078,000

The development of photovoltaics is keyed to advances in materials science and technology. Modules based upon crystalline silicon cell materials have been commercially available for a number of years and are now cost effective in high-cost electricity markets. In the past year thin-film amorphous silicon cells and modules have become commercially available from U.S. industries as a result of government/industry collaborative research efforts. This partnership with industry was responsible for re-establishment of a U.S. amorphous silicon research effort and continues in FY 1987 with a cost shared program for the advancement of the scientific base in amorphous silicon-based alloy materials.

In the longer term, it is projected that through cost shared research on thin-films and advanced high efficiency materials, higher-performance lower-cost photovoltaic power systems will become competitive with conventional electric power systems.

Research will emphasize single and multijunction alternatives across three major material groups. The first is amorphous silicon and the alloying elements of hydrogen, nitrogen, carbon, fluorine, germanium and tin. The second group includes high efficiency silicon and gallium arsenide concepts for application in flat-plate and concentrator collectors. Advanced thin film II-VI materials and compound alloy materials such as copper indium diselenide and cadmium telluride constitute the third materials research area. Research on performance, stability, and lifetimes of all three groups involves investigations ranging from material characterization and deposition techniques to module fabrication and test.

A more fundamental photovoltaic research effort will support university research and training, promote the development of new ideas, and explore innovative concepts in materials, device structures, conversion concepts, and characterization methods.

A focused technology transfer effort to assure that ten years of research information is used to the best possible advantage by industry and potential users will be undertaken through technical documentation, workshops and technical symposia.

The FY1987 budget request for photovoltaic energy systems is $20,600,000. This represents a $26,548,000 decrease from the FY1986 adjusted appropriation. Funds totaling $19,600,000 will be used to support the following research areas.

-- Amorphous Silicon for Single and Multiple Junction Cells: R&D activities will be conducted on issues important to cell performance, stability, and fabrication. The work encompasses material selection and characterization; deposition technology; characterization of films, surfaces and interfaces as a function of deposition parameters and methods; measurement of diffusion lengths, minority carrier lifetime, alloying characteristics, and surface and bulk recombination rates; modelling and analysis of materials and cell structures; and comparison with investigations of causes and remedies for light-induced degradation of amorphous silicon cells. Special emphasis will be on multiple-junction amorphous silicon devices using alloying elements including hydrogen, nitrogen, carbon fluorine, germanium and tin. Multiple-junction (stacked) photovoltaic devices offer the possibility of achieving higher efficiencies than single-junction devices. The additional efficiency may more than offset expected additional complexity and thus result in potentially less expensive energy production. These devices will be fabricated as monolithic stacks.

-- High-Efficiency Research: Although the theoretical conversion efficiencies of silicon cells and (III-V)-based cells are greater than 25 percent, the typical value for these materials is less than 20 percent. This activity will support materials, device and modelling research to achieve longer-term one-sun efficiency objectives of 22 percent and 27 percent, for silicon and gallium arsenide, respectively. It will also support research on high-efficiency multiple-junction concepts having the potential to achieve 25 to 35 percent cell conversion efficiencies for application in flat-plate and concentrator collectors. The high-efficiency cell concepts are largely based upon single-crystal, thin-film materials stacked vertically as grown or as placed in a mechanical configuration. The current state of material purity, deposition equipment and interface effects and techniques are all scientific challenges to be resolved. Modelling studies and theoretical analysis are required to guide the device research and the much-needed increases in advanced cell efficiency.

-- Advanced Thin-Film Devices: Single-junction polycrystalline thin-film cells have received federal and industrial R&D attention during the past ten years. Conversion efficiencies of a number of thin-film cells have doubled during this time, but have not reached their projected practical potential. Many R&D opportunities need to be explored to obtain higher-performance (e.g., conversion efficiency, stability and lifetime) and lower-cost cells and modules. Advanced thin-film materials showing the most promise include: copper indium diselenide (CuInSe2) and cadmium telluride (CdTe). The improvements of single-junction cells will be applied to the development of higher-efficiency, multiple-junction cells, which are often based upon combinations of the same materials. The program will continue to support research to produce improved heterojunction (junction formed between two different materials) and homojunction (junction formed by adjacent layers of the same material with different doping) devices based upon compound semiconductor materials. The longer-term goal of more than 15 percent laboratory cell conversion efficiency by 1987 is expected to be met under this project.

-- Photovoltaic Fundamental Research: The objective of this program element is to support university research and training, promote the development of new ideas, and explore innovative concepts having significant interest and potential impact on photovoltaic science and technology. This thrust is aimed principally at projects and efforts expected to make substantial long-range contributions to the advancement of photovoltaic conversion through coordinated basic and applied research conducted by universities in support of the national program goals. Particular attention will be given to the needs of universities in fulfilling their missions and in creating conditions promoting their maximum contributions to the photovoltaic technology base. Research, new ideas and innovative concepts are expected to include new semi-conductor materials, device structures, conversion concepts and characterization methods.

-- Technology Diffusion: The National Photovoltaic Program has amassed a wealth of information from materials to systems during its ten years of research and development. This activity is a focused effort to assure that such research information is used to the best possible advantage by the industry and the user. Through technical documentation, workshops and technical symposia, information will be transferred and further research identified that will bring photovoltaic technology to competitive maturity domestically and internationally.

Capital Equipment

Funds totaling $1,000,000 are needed to upgrade and procure equipment for the Solar Energy Research Institute (SERI) and university laboratories. This equipment is needed to implement (a) new measurement techniques to analyze and evaluate materials and device structures, and (b) improved deposition methods for laying down controlled thin-films of materials to formulate new thin-film devices. In particular, these funds will help maintain SERI at the forefront of photovoltaic materials characterization.

	FY 86 Adjust. Appropriation	FY87 Request	Net Change
SOLAR THERMAL ENERGY SYSTEMS	$25,885,000	$15,300,000	-$10,585,000

The goal of the Solar Thermal Technology program is to advance the engineering and scientific understanding of solar thermal technology and to establish the technology base from which private industry can develop solar thermal power production options for introduction into the energy market. The FY 1987 budget request for Solar Thermal is $15,300,000, which is a $10,585,000 decrease from the FY 1986 adjusted budget of $25,885,000.

Through concentration and heat absorption, solar thermal energy can be converted into electricity or incorporated into products as process heat. Highly reflective surfaces or refractive lenses are arranged geometrically to focus on a receiver which converts the radiant energy into transportable heat. Solar thermal technologies can supply energy for applications over a broad range of sizes and temperatures. Solar thermal energy can also be stored, extending useful operation into non-daylight hours. Another option is hybridization using a fossil fuel combustion source, which increases reliability and offers the benefit of constant power output even at low levels of insolation.

The "National Solar Thermal Technology Program, Five Year Research and Development Plan" outlines federal research activities that will be pursued to achieve the needed technology base from which industry can choose appropriate solar thermal energy options. This plan provides the basis for solar thermal technology planning and reporting. The plan identifies eleven research tasks in three major areas; collection, energy conversion, and systems and applications. The tasks are designed to achieve technical improvements in the most promising solar thermal concepts. With the maturity of the technology progressing well, the Solar Thermal Program is in a position to encourage cooperative venture research and development projects. Three specific collaborative activities to be to be continued in FY 1987 are the development of stressed membrane distributed concentrators (parabolic dishes), scaled up central receiver molten salt receivers and automated control systems.

Collection Technology Research

The energy collection process consists of the concentration and transmission of sunlight by a concentrator such as a heliostat (for central receivers), parabolic dish, parabolic trough, fresnel lens, or other optical concentration device, to a receiver where the sunlight is converted to thermal energy. The collection technologies research areas are; optical materials, concentrators, and receivers.

The objective of this research is to identify and characterize, collection materials and components suitable for stable long-life performance in concentrating solar applications. Concentrating solar thermal technologies have great potential for inexpensive energy production. To better realize this potential; light-weight, high performance reflectors, hign-temperature receivers, and concentrators must be evaluated.

The specific FY 1987 research activities that will be conducted are:

- Optical Materials

  Research in optical materials includes identification and characterization of reflecting materials; fundamental evaluation of the failure mechanisms of optical surfaces, degradation mechanisms in polymers, high-absorptivity coatings, high-temperature measurements; and research on refracting optics to determine optical requirements and the appropriate tradeoffs between cost and useful life. The objective is to develop a lightweight reflector that is of comparable quality to a glass mirror. In particular, this means a reflector over 90% reflectivity with a useful life over 5 years. This will be accomplished primarily through research on silvered polymeric reflector materials and a front surface mirror concept where the silver is protected by a solgel compound.

  Concentrators made of silvered polymers or silvered stainless steel have the potential for a substantial reduction in the weight and thus the cost, of the single largest capital cost item of solar thermal systems. The requirement of high-specularity and long-term UV protection is a requirement which is unique to the solar thermal program. This materials research area is aimed at understanding the relationship between the solar flux and the polymer, silver and sol gel. The polymer and sol gel must then be modified to protect the silver reflective surface. Chemical interactions between the silver, polymers, sol gel and stainless steel must be understood and eliminated. Accelerated testing is underway to understand the degradation of polymers from ultraviolet radiation as well as from other environmental factors.

- Concentrators

  Solar concentrators for central receivers, parabolic dishes or parabolic troughs comprise 35-50% of the cost of the system. Maintaining performance while decreasing the cost of concentrators is the biggest single opportunity for bringing the financial risks of solar thermal systems down to a range where private industry can assume control of development. Decreasing the weight of the concentrator has a direct relation to decreasing its cost. Much of the effort in this task focuses on understanding materials' properties, developing mathematical analyses and conducting performance and environmental testing of concentrators to verify those analyses. This effort, done in conjunction with industry, is to determine if the concepts are approaching the multi-year program objectives.

  The specific objective is to decrease the weight of concentrators by at least 55% while increasing the annual efficiency by 5%. The principle concentrator concepts to be investigated include silver/polymer and silver/ stainless membranes and Fresnel lenses. Sufficient progress has been made that it should be possible to use an industry cooperative venture for the development of attractive parabolic dish concentrators. Important these tasks is gaining an understanding of the force between the new lightweight reflector materials being used and the structures supporting them at various loading conditions. Research will also explore methods of reducing the wind load on a field of concentrators, particularly heliostats and parabolic dishes, through analysis and wind tunnel modelling. Testing and evaluation of stretched membrane heliostats and dishes and innovative point focusing concentrators, began in FY86, will continue.

o Receivers

Solar receivers represent the highest technical risk area in central receiver solar thermal systems. Important heat transfer and thermal cycling data concerning receivers is not well understood: making them both heavy and costly. This task aims at better identifying thermal cycling and loss mechanisms, which will lead to improved thermal and structural designs. The objective is to decrease the technical risks and thus the cost of receivers, principally for central receivers, while maintaining or increasing their annual efficiency. In order to do that, several significantly differing concepts must be evaluated.

One concept is the "optimum" receiver. This concept integrates the thermal analysis on tube and cavity receivers with the lessons learned from the Barstow Solar One and Molten-Salt experiment receivers. This optimum receiver, designed in FY86, incorporates significant changes to reduce technical risks and expands the state-of-the-art in receivers. Testing will be initiated at the CRTF during FY87 and/or at Barstow in FY89. This is another area that offers the possibility of pursuing a cooperative research and development venture. Previous cooperative development projects in this category have been performed on pumps, valves and smaller scale receivers. One highly advanced concept being evaluated is the direct absorbing receiver in which the solar energy is absorbed directly into the working fluid without need of tubes. Such a concept has the potential to increase the efficiency while significantly reducing the material risks of thermal expansion and cycling and the cost of receivers. The concept also has the potential for working at temperatures up to 900±C. Receiver evaluations will consist of thermal modeling to quantify convective and radiative losses, design receivers and conduct preliminary testing at the CRTF.

This task also supports an area of research that may lead to better utilization of the concentrated solar flux. Combustion receiver/reactors will take advantage of high energy photons to initiate certain chemical reactions and the remaining portion of the solar spectrum will provide the heat necessary to complete the reaction. Thus, this task addresses both the need of reducing the risks and the need for broadening the applicability of solar thermal systems.

Energy Conversion Technology Research

The objective of this research is to identify processes and components to convert thermal energy into electricity or other usable energy forms such as fuels and chemicals. It includes thermal or thermochemical processes for transporting energy, and also thermal and chemical energy storage.

The specific FY 1987 research activities that will be conducted are:

- o Heat Engines

Heat engines convert the concentrated solar energy to electricity. The efficiency of the engine is the largest contributor to the overall system efficiency. The engine is also, because of its rotating parts, the most likely part of the system to break down. For the longer term, this task addresses these problems through research into new concepts: which are direct conversion engines with high-efficiency and high-reliability. Although heat engines are used in central receiver system this task area deals primarily with heat engines for parabolic dish mounted applications because of critical problems in that application.

The objective of this research task is to reduce the expense of dish mounted heat engines below $400/kWe while increasing the annual system efficiency to 25%. It appears that current engines, (organic Rankine, Brayton, and kinematic Stirling cycle) cannot meet the program goals and emphasis has shifted to new advanced engines. The principle engines to be studied are the free-piston Stirling engine, the sodium heat engine (SHE) and the regenerative thermo-electrochemical engine (TECH). These devices convert the sun's energy to electricity with almost no moving parts. All are highly efficient and have the potential for low operating, maintenance and capital costs. In addition, they operate over different temperature ranges which makes it possible to combine two engines to provide an overall efficiency (heat to electricity) of nearly 50%. Research will continue to determine their technical feasibility and on integrating them into solar systems. Technical problems will have to be solved in system control, short-term energy storage, and containment materials.

Additional tasks will continue evaluations of organic Rankine and other engines as needed to support the testing phase of the Small Community Solar Experiments at Osage City and Molokai. This support will insure that the experiments are successful. Since these engines are still in the development stage it is anticipated that they will have periodic maintenance problems, such as oil or gas leaks, bearing failures, or control breakdowns that need to be addressed.

- o Direct Conversion Devices

Solar thermal systems have been used to convert concentrated solar energy into heat which is then used directly for an industrial process or converted into electricity via a heat engine. Preliminary research has indicated that other (perhaps unique) characteristics of concentrated solar flux can result in other high value applications. This research does not degrade all of the solar spectrum to heat, but separates the high energy photons for direct use. It is expected that this small percentage of the spectrum will have a large effect on many processes. Most of the spectrum is still used to produce heat for an endothermic type of reaction.

The objective of this research task is to more completely utilize the unique properties of concentrated solar flux. High energy photons in the UV and near-UV portion of the spectrum may be able to initiate a variety of chemical reactions not possible by other sources of energy. This, and other unique properties of concentrated solar flux, may provide new applications for solar thermal systems. Research will continue into the basic interaction of flux on materials and various chemicals in order to determine how the energy is transferred. In addition, research will continue to determine if the very high heat transfer rates produced by solar thermal systems can benefically alter the reactant path of chemical reactions. Examples of the applications being studied in this task include the solar detoxification of hazardous organic wastes and the photo-catalytic formation of ammonia from air and water. These would be entirely new applications of solar thermal energy: the direct coupling of the flux to the chemical reaction. Related research is also conducted to shift and separate the solar spectrum so those particular portions that are most beneficial to a particular reaction can be maximized and used efficiently.

o Transport and Storage

Solar energy is intermittent and periodic by nature. Storage allows the system to operate continuously during cloudy periods and additional storage can extend the period of operation into night-time hours. Long-term storage is important because it allows solar systems the flexibility to meet the needs of the user: whether it be a chemical plant or utility. As long as solar systems can operate efficiently only during daylight hours they will have a sharply restricted applicability. Thermochemical processes offer the potential for an efficient storage and transport that would greatly enhance the efficiency and flexibility of solar thermal systems.

The objective of transport and storage research is the evaluation of transport and storage systems that can provide an effective match between the fluctuating solar energy resource and the thermal, electrical or chemical load demand. The two primary methods of energy transport and storage are thermal and chemical. This task in FY87 is concerned primarily with chemical transport and storage. Chemical storage/transport has the advantage in that the chemicals are stored and transported at ambient temperature, thus eliminating much of the thermal losses.

The key to the feasibility of this is the efficiency of the endorthermic reaction at the solar receiver and the exothermic reaction at the point of application. Research during FY87 will determine these efficiencies through the test of experimental reactors. Depending on studies conducted in FY86 either the CH_4/CO_2 reforming or SO_2/O_2 reactions would be used. Problems that must be addressed include catalyst degradation, thermal cycling of materials and control of side reactions. An additional task in the thermal storage area looks at methods of reducing the risks of transporting and containing high-temperature molten salt from central receiver applications.

Systems & Applications Technology Research

The objective of this research is to conduct system evaluations and parametric and comparative analysis at an early stage to assess the potential of alternate concepts, and to define critical technology and component issues. This research effort includes the evaluations of existing designs, components, subsystems and systems. Support for scientific and engineering experiments are included as necessary to achieve program goals.

Research areas include: 1) the assessment of innovative concepts and applications; 2) balance-of-plant components; 3) the analysis, design, and experimental testing of central and distributed receiver subsystems and systems at research facilities and also: 4) support for the design, construction, operation, and evaluation of complete systems at user locations.

The specific FY 1987 research activities to be conducted are:

o Balance of Plant

Reducing operating and maintenance requirements are critical in solar thermal systems. This becomes increasingly important as the size of the plant decreases. For a small solar thermal plant to be economically competitive, unattended operation and monitoring is probably necessary. This task is intended to address that issue by applying state-of-the-art artificial intelligence technology to solar thermal systems. This task also studies the maintenance requirements of the systems to keep the plants operating at maximum efficiency and reliability.

The objective of this research task is to minimize the risk and expense associated with the operation and maintenance of solar thermal systems; principally through the development of innovative maintenance approaches and control systems that would allow for unattended operation. Rapid advances in electronics and artificial intelligence makes it possible for state-of-the-art sensors and computers to monitor and control the thousands of heliostats or parabolic dishes and other components and subsystems that make up a solar system. Experimental control systems will be designed and evaluated to support the Small Community Solar Experiments and the central receiver system experiments at the CRTF. These applications are representative of small dish and central receiver systems and are likely to be cooperative venture projects with industry cost sharing. Maintenance concepts, such as concentrator cleaning methods, improved heat tracing, and more routine maintenance requirements, will be evaluated to improve system performance and reliability.

o Central Receiver Systems

The general objective of this research task is to determine the technical applicability of small-scale central receiver experiments to full size systems. Testing of small-scale hardware is vitally important to provide solutions to "real world" problems that do not show up in the laboratory environment. It is through these tests for example, that many materials problems first surface. These tasks also give industry and utilities confidence that the technology is appropriate to their application. The ability of the researchers to prove the scaleability of their test results to larger systems is key in convincing these users that the technical risks are understood and can be overcome without further scientific breakthroughs. This task is thus a form of technology transfer from government to industry of central receiver hardware concepts that have proven to be technically feasible.

Central receiver system research activities include the development of designs, the analysis of system parameters and the experimental testing of groups of components, leading to the evaluation of prototype subsystems and systems. To support these objectives small scale experiments of central receiver components and subsystems will be designed and conducted at the CRTF to verify such items as the scaleability of heat losses, heat tracing and receiver tube. Mathematical analysis, including computer code development, will integrate advanced components into a system for concept comparison and to provide guidance for future research. One such study, completed in FY86, determined the feasibility of high-temperature systems. This study for example influenced the direction of the task on "Receivers". Another major activity will be tradeoff and conceptual studies to support the determination of the next appropriate step in central receiver technology.

o Distributed Receiver Systems

Laboratory tests are not able to exactly simulate the solar spectrum nor the environmental conditions that field hardware must actually withstand. Tests at the DRTF are thus valuable from a diagnostic point of view. Hardware performance is also used to verify the mathematical analyses and computer codes that were used in each design stage. This correlation of theory and working modules is a key factor in convincing industry and utilities that the technical risks are understood and can be overcome.

The objective of this research task is the verification of mathematical analyses of distributed receiver systems (dishes and troughs) through laboratory and DRTF testing and evaluation. The dish module for the Small Community Solar Experiment at Molokai, Hawaii will be tested during FY87 before it is approved for Molokai. Analyses will be conducted comparing the performance of dish modules to the requirements for reflector accuracy, and structural rigidity, and the usefulness of terminal concentrators for a variety of operating temperatures.

o Systems Experiments

System experiments at user sites provide data on capital and O&M costs, performance, reliability and operations and maintenance techniques and problems of solar thermal systems. Experiments are conducted with significant cost-sharing from equipment manufacturers and potential users. Such experiments support the achievement of technical and economic feasibility and are intended to provide the final impetus for industry to commit to full development of the technology.

The objective of this task in FY 1987 is to evaluate data generated from system experiments at the Solar One Pilot Plant at Barstow, California and the Small Community Solar Experiments at Osage City, Kansas and Molokai, Hawaii. This data provides valuable insight into the long-term material and component problems that may not have been predicted in laboratory tests or prototype evaluations. Most of the funding in this task is the DOE contribution to the Solar One cooperative agreement for operations and maintenance of the facility.

Planning and Assessment

The objective of this activity is to conduct program integration, assessment, comparative analysis and specific technology transfer activities such as program documentation and periodic contractor review meetings. Solar thermal activities will be continued to support implementation of the Five-Year Research Program Plan.

	FY 1986 Adj. Approp.	FY 1987 Request	Net Change
BIOFUELS ENERGY SYSTEMS	$27,326,000	$12,200,000	$15,126,000

The goal of this program is to conduct a balanced research effort aimed at providing the generic technology base for industry in the areas of feedstock production and conversion. The objective is to provide early transfer of technology to the private sector by verifying technical feasibility/readiness of combined feedstock production and conversion technologies through cost-shared projects.

The purpose of Short Rotation Intensive Culture research is to establish the technology information base needed to enable the private sector to increase the production of wood energy feedstocks in targeted areas using short rotation intensive culture (SRIC) of woody plants. The objective of increasing potential productivity will be approached through genetic improvement combined with advances in innovative cultural management strategies. Biological evaluation of management alternatives includes evaluation of stem regrowth (coppice) following harvest and assessment of disease and pest risks. The objective of improving the technologies of SRIC will be addressed in FY 1987 through identification of efficient cultural strategies using improved genetic material and through evaluation of nutrient conservation mechanisms. Analyses indicate that SRIC of woody plants is a technology which once developed by the private sector has the potential to supply wood users with an assured, sustained wood supply at competitive prices and without Federal subsidies in areas where it is most needed.

Genetic improvement of species offers the greatest potential for increasing the productivity of SRIC. Classical genetic selection for new, highly productive families and energy clones will continue. Researchers believe that additional productivity gains of up to 90% are possible through genetic improvement. Candidates have been selected for genetic selection and future hybridization.

Prior research indicates that coppicing results in productivity gains of at least 30%. However, additional data are needed to verify that stands can be cut repeatedly without loss in regenerative power. Coppice evaluations will be examined on established test plots. These management techniques will be evaluated, and species or clones that show the best generation-based coppice potential will be identified. Data will be simultaneously obtained on techniques for increasing coppice growth and optimum number of harvests. Successful coppice growth is a major key to viability of SRIC.

Monoculture viability studies will be conducted to determine the biological risks of growing single species of trees under intensive culture conditions. In particular, susceptibility to diseases and pests will be identified, and operational yields will be determined. Industry is expected to cost-share equally in these experiments.

Nutrient conservation studies will address the environmental concern of SRIC-caused nutrient depletion on marginal agricultural land. Quantification of nutrient cycling mechanisms under a series of management approaches will be conducted to determine the best management regime for reducing costs and maintaining site productivity over the long term. Critical nutrient elements will be identified and ameliorative strategies evaluated.

The purpose of Herbaceous Energy Crops research is to provide the technology base that will allow the private sector to develop commercially viable systems for producing herbaceous biomass for fuels and energy feedstocks. The program focuses on lignocellulosic crops versatile feedstocks for biochemical and thermochemical conversion systems. In addition, effort will be devoted to oilseed crops. Analysis has indicated that herbaceous energy crops grown on marginal lands have high potential for a significant energy contribution and is a research area of high priority.

The goal of the Herbaceous Energy Crops program is to obtain yields of up to 12 dry tons/acre/yr. Experiments designed to select species or cultivars with high productivity on marginal croplands and to define promising approaches to production systems will be performed. In addition, experiments on the use of in-vitro systems for selecting and improving species for use on sites with specific chemical or physical limitations to production will be conducted.

In FY 1987 oilseed crop research emphasizes breeding and testing of new varieties of winter rapeseed for liquid fuels. Resistance to the herbicide atrazine will be bred into varieties of winter rapeseed whose fatty acid composition has been adjusted to maximize the fuel value, permitting the control of weeds related to rapeseed in rapeseed fields. Limited variety trials designed to establish planting dates, harvesting dates, and yields for rapeseed varieties will be evaluated.

The purpose of Aquatic Species research is to improve the productivity of microalgal species, and the efficiency of conversion processes for these species, to the extent that private industry will develop these technologies for liquid fuels. Microalgae are widespread in nature, possess rapid growth characteristics and diverse chemical composition, and provide a potential resource base for producing renewable fuels. Microalgae production is designed to provide a domestic source of high-energy liquid fuels, such as gasoline and diesel fuels, which complement and contribute diversity to the nation's overall energy mix. Research will focus on selecting and improving strains of microalgae to provide high, sustainable yields of fuel products in outdoor mass culture.

FY 1987 funds for microalgae will be used for those research areas identified as critical for further advancement of the technology: species screening, species improvement and outdoor culture strategies. In the species screening area, effort will be directed to complete characterization of strains for lipid yield, growth potential, and environmental tolerance. Carefully characterized strains will lead to selection of species on which to concentrate species improvement activities. The critical issues are: isolating species which possess high growth rate and high lipid production and isolating organisms with high growth rates at low temperature.

One goal of microalgae research is to improve lipid production from 20-30% of the organism by weight to 50-60%. In an effort to produce strains of microalgae with the ability to produce a larger percentage of lipids, research into the regulation of lipid synthesis will be conducted.

Mass culturing of microalgal species in small outdoor experimental facilities is imperative to the advancement of this technology. The objectives of this research are to verify the performance of laboratory-selected species in an outdoor setting and to devise strategies for maintaining high yields of lipids in the mass culture environment. Sensitivity to temperature and light are critical variables.

Thermochemical conversion will focus on the production of liquid fuels from biomass and the thermochemical processing of municipal solid waste. Liquid fuels have higher energy density than biomass feedstock and are able to be transported more economically and to be more easily stored. Liquid fuels also match existing end-use patterns, particularly in the transportation sector. Research in this area will be directed at identifying reaction pathways and methods for producing high-value liquids fuels and on improving yields and quality of liquid fuels. Municipal solid waste (MSW) research will continue to address the production of liquid and gaseous fuels by thermal processes, as part of the overall goal of assisting industry develop sound technologies for the productive use of municipal wastes.

In FY 1986 a major thrust of the biomass portion of this program element dealt with medium-Btu gasification. An industrially cost-shared experimental facility of 50-200 tons/day capacity will be constructed with FY 1986 funds and serve as a centerpiece for medium-Btu gasification. Industry is expected to assume responsibility for further applications development.

In the liquid fuels research area, fast pyrolysis and pressurized catalytic liquefaction will be evaluated in continuously-fed bench scale reactors and in process research units. This research will provide important information required for determining some of the necessary process conditions and expected yields of biocrude oils. The concept of fast pyrolysis has emerged as a promising alternative for producing liquid fuels. Using rapid heating rates, yields of gases and liquids as high as 95% can be produced. These products contain up to 20% high-value olefinic products such as ethylene and aromatics such as benzene, toluene, and xylene, which are potentially useful as fuels and octane enhancers. The pyrolysis research will focus on investigating extremely fast pyrolysis to maximize yields of high-value octane enhancers improving the yields of fast pyrolysis by conducting the reactions in an atmosphere of a reactive gas, and using fast pyrolysis to produce high yields of fuel oil substitutes.

Laboratory research will be conducted on the thermal stabilization of pyrolysis liquids with emphasis on reaction concepts for manipulating the decomposition reaction mechanisms of these unsuitable oils to prevent polymerization into heavy tars. Experiments will examine those process conditions which contribute to the production of paraffinic hydrocarbons in the desired boiling range in preference to the aromatic hydrocarbons.

The pressurized catalytic liquefaction research focuses on using a unique extruder/mixer design to investigate direct conversion of biomass to liquid fuels. This research will also provide the necessary feedstocks for research on refining these oils into gasoline compatible fuels.

Municipal solid waste research will focus on developing basic kinetic data for thermal liquefaction and gasification. The research is aimed at defining the primary and secondary chemical reactions, identifying some of the important operating parameters and how they influence the reactions, and producing a useful kinetic model that can be used by industry for design of efficient reactors to produce gaseous or liquid fuels. The scientific basis of heat transfer in MSW will be examined in order to establish fundamental data necessary for the design of efficient reactors.

FY 1987 funds will also be used to examine the most serious current problem in the implementation of emerging MSW thermochemical technologies as identified by industry, i.e., the understanding and control of trace chlorinated hydrocarbons. Research will address the understanding of chlorine sources, conversion and destruction of trace pollutants and, as an added energy bonus, the understanding of the combustion kinetics of MSW which is expected to lead to a 5% increase in the efficiency of waste-to-energy processes. In the MSW feedstock preparation area, research will focus on integrated models of preparation systems and the development and testing of suitable binders. The successful development of refuse-derived-fuel (RDF) from MSW will lead to cofiring of RFD in existing boiler facilities.

Research in biochemical conversion will be performed to provide the technology data base for conversion of cellulosic and lignocellulosic materials from renewable resources into high-value liquid and gaseous fuels. Effort will focus on the biology of microbial processes for enhanced product yields, high conversion efficiencies, and rapid kinetics of reactions, all of which will contribute to viable processes for alcohol fuels and methane-rich gases. Funding in FY 1987 for alcohol fuels will advance the technology for competitive production of octane enhancers and additives for transportation fuels. Further developments in alcohol fuels research have the potential to lead to neat transportation liquid fuels competitive after the turn of the century. The anaerobic digestion of dedicated feedstocks, biomass grown specifically for the digestion process, and municipal solid waste are high risk research areas with potential for significant pay-off. FY 1987 funds will be used for anaerobic digestion research to reduce the technical risks and enhance private sector involvement. Increased conversion efficiencies, improved rates of digestion and fermentation, and better pretreatment methods are research areas where improvements are targeted to sufficiently reduce risks to attract private sector investments.

FY 1987 ethanol production research will focus on conversion of the hemicellulose fraction of wood to ethanol, improvements in the yield of ethanol from cellulose, and conversion of lignin to liquid fuels. Available yeasts cannot convert the five carbon sugars present in hemicellulose to ethanol. Genetically modified yeasts to perform this conversion will be examined, potentially increasing the ethanol yield by about 40 percent per unit weight of wood processed. To improve the performance of enzymatic hydrolysis, chemical pretreatments will be tested to determine their ability to improve the conversion efficiency in various hydrolysis/fermentation schemes. Research will be directed at cellulose enzymology to increase the productivity of enzyme producing organisms and, furthermore, increase the activity of the enzymes produced. This work will also include research on enzyme recycle. Increasing enzyme productivity and activity, as well as, enzyme recycle have been identified as major cost cutting steps to any enzymatic hydrolysis process. In FY 1987 a selection will be made to persue one of the three acid hydrolysis processes currently under study. In FY 1987, research will address the transformation of lignin into octane enhancers and liquid transportation fuels, as well as there use in integrated process schemes to produce liquid fuels in order to use the 20-35 percent of a tree that is lignin.

The focus of the biochemical conversion of biomass to methane rich gases will be to enhance stability and control of anaerobic digesters with dedicated herbaceous crops as the feedstock. This research will enhance the favorability of digester construction and operation, thus eliminating the need for back-up systems and oversizing for safety. For efficiency, the digester must be operated at close to maximum loading rate as possible. Research is needed to determine the biological markers that indicate digester failure, then control systems can be designed that will permit operation at nearly maximum levels. In order to meet the objectives of enhanced stability and control, monoclonal antibodies will be developed for specific organisms in the microbial consortium. These biological markers will allow populations of individual organisms to be monitored before, during, and after digester failure.

Biochemical conversion of municipal solid waste will focus on processes that biologically convert MSW to gaseous fuels. Research will address understanding the life-cycle of microorganisms involved in anaerobic digestion and the modification of these organisms to enhance their productivity. The understanding of the biochemistry and physiology of the ecosystem is essential in the study of methanogenesis for improved digester performance. Research on this cost-shared project will involve methods for injection of refuse derived fuel into the digester, filter care dewatering tests, and optimization of solids content. The private sector is expected to embark on a commercialization of this process pending outcome of the remaining R&D.

FY 1987 funds for capital equipment will be used for analytical equipment and laboratory scale apparatus to support research in biofuels production and conversion. The funds will be equally divided between production and conversion research.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Wind Energy Systems.............	$24,825,000	$8,250,000	$-16,575,000

The principal objective of the Wind Energy Program is to improve the understanding of fundamental atmospheric processes and their effects on wind turbines and to translate this understanding into tools that the industry can use to design and operate cost-competitive wind turbines. The proposed FY 1987 budget continues the industry/government partnership defined in the recent multi-year plan. The cost, performance and structural lifetime of today's wind turbines must be improved substantially for the industry to be cost-competitive over the long-term. The FY 1987 request for Wind Energy Systems is $8,250,000. This represents a $16,575,000 decrease from the FY 1986 adjusted appropriation of $24,825,000.

The DOE R&D program is structured to assist industry in these developments with two major technical thrusts. The first element is Basic Science of Wind Turbine Dynamics. This thrust includes efforts to understand the random nature of the wind, its complex interaction with the wind turbine rotors, and the effects of this interaction on performance and reliability. The second thrust is Advanced Components and Supporting Research. It is structured to assist industry in identifying promising advanced concepts, such as high performance airfoils.

The FY 1987 request reflects a revised budget structure to implement the above strategy. The majority of the effort included in previous years in the aerodynamics and structural dynamics research elements related to improved understanding of fundamental processes is now in respective subelements in Basic Science of Wind Turbine Dynamics. Similarly, research on advanced airfoils is now proposed under the Advanced Components and Supporting Research element.

Major changes in the request include the completion of vertical axis research in FY 1987 and the phase-out of Mod-5B in FY 1986.

Implementation of research is undertaken through universities, industry, and Federal laboratories, including the consolidated Wind Energy Research Center at Rocky Flats operated by SERI.

BASIC SCIENCE OF WIND TURBINE DYNAMICS

This element is the major technical effort in the DOE wind program and reflects the program structure in the recent multi-year plan. Its subelements are atmospheric fluid dynamics research, aerodynamics research and structural dynamics research, and efforts are focused on improved understanding of how a turbine produces energy.

Atmospheric Fluid Dynamics Research

The need for improved understanding of the local behavior of the wind is demonstrated by experience at windfarms and DOE experimental turbines. In windfarms, many turbines perform poorly, while others experience blade fatigue failure after 2 to 3 months. The major drivers of these operating problems are turbulence induced loads, local (micro-scale) windflow variability and shear, and turbine- to-turbine interaction through the wake of the upwind turbine. These research issues are addressed in this element.

o Microscale Turbulence

Turbulence is a primary driver for fatigue loads experienced by a wind turbine. It is also a very complex phenomenon that varies widely, both spatially and temporally, and is hard to quantify because it is difficult to visualize. Existing models do not satisfactorily represent the stochastic properties of turbulence. DOE research experience and the operational histories of commercial windfarms indicate that turbines with adequate lifetimes cannot be built without a full understanding of turbulence and its influence on aerodynamic lift and structural loads.

Projects proposed will continue rotational sampling research to better represent the wind that a rotating blade encounters and will include basic characterization of the free stream wind input to the turbine, modification of the turbulent wind by the rotor, and improvement to the stochastic wind turbulence models.

- Local Flow and Performance Variability

The performance of individual machines at existing windfarms in complex terrain can vary significantly due to the influence of hills and obstructions at nearby sites. The ability to predict wind speed and direction variations at individual sites would be a great assist to a windfarm developer. Recent progress in verifying a mass-consistent wind flow model with digitized terrain input suggests that this technique is feasible. It would allow turbine installers to avoid siting turbines in locations with especially turbulent or marginal winds. Requested funds would support field validation and theoretical extensions of the models by conducting a multi-site wind measurement program at several locations in mountainous terrain with differing climatic characteristics.

Aerodynamics Research

Understanding the aerodynamic processes that convert the kinetic energy of the wind into mechanical and electrical power is the principal challenge facing the wind energy research community. It is made complicated because the wind input is turbulent, the aerodynamic processes are themselves unsteady and produce turbulence, and radial flow may occur along the blade. Major areas of research include unsteady flow and aeroelastic theories, aerodynamic performance code improvement, and cooperative research with industry. This research is generic in nature and generally independent of turbine size and configuration.

- Unsteady Flow and Aeroelastic Theory

Unsteady aerodynamic effects are believed to be a primary cause of inaccurate prediction of lift and stress in wind turbines and resulting uncertainties in fatigue life and system reliability. In wind tunnel tests on airfoil sections operating with rapidly changing angles of attack representative of turbine operation, dynamic stall has been shown to produce widely varying lift coefficients. The effects of three dimensional flow along the blade are particularly difficult to model or simulate, but are likely to be a significant source of error in predicting stall and performance of intermediate turbines. These factors can not currently be simulated in wind tunnel tests. Requested funding would support advanced wind tunnel testing and refinement of theoretical models.

- Improved Aerodynamic Codes

Existing aerodynamic computer codes are very large, complicated to use, and underpredict cyclic lift and drag forces by as much as a factor of two. Key refinements to reflect dynamic stall, turbulence and three dimensional flow are needed. Requested funding would provide for upgrading computer codes, and simplification where possible, using theoretical extensions developed in the previous subelement.

- Cooperative Research with Wind Turbine Manufacturers and Windfarm Developers

Cooperative research with industry is a key element of the Federal Wind Program. A large body of research data is potentially available from the 8000 or more wind turbines installed in windfarms by the end of 1985. Building on approximately 5 projects started in late 1985, and 5-10 in FY 1986, this subelement permits improvement and validation of aerodynamic and structural theories developed over many years and expedites information exchange between government and industry. These projects are awarded competitively, with maximum industry cost-sharing and minimal Federal paperwork. Tests will be conducted using specially instrumented commercial machines to obtain actual operating data collected in a wide range of environments. This "real world" information will be used to improve understanding of turbulence, aerodynamic performance, wakes and micro-siting, and supporting research.

Structural Dynamics Research

The objective of the structural dynamics research element is to improve understanding of how aerodynamic loads induce structural stresses and resulting fatigue, and, to develop and validate computer codes to permit industry to design wind turbines with a 20 to 30 year life. Current machines have been shown to develop blade problems in less than 3 years, far short of their design life. The reasons for this are not well understood.

Structural design of a wind turbine, given the severe operating environment, particularly with respect to fatigue, is a very difficult task. It requires understanding of the wind as a forcing function, aerodynamic and electric power system processes acting on the structure and how the structure responds. Sources of deterministic loads, i.e. gravity, centrifugal forces, average wind, and start-up/shut-down cycles, are reasonably well understood and modeled satisfactorily. However, loads generated by turbulence and unsteady aerodynamic processes are not well understood and are a key uncertainty. Methods of predicting ultra-high cycle fatigue lifetime for wind turbines are limited in capability and confidence levels.

o Frequency and Time Domain Models

Improvement of structural models to reflect the wind turbulence input, time varying aerodynamic loads, and variable rotor speed operation is essential to the design of cost-effective systems. Modeling interactions among the principal turbine components--blades, rotor, drive trains, and tower--and their interactions with the wind and the electric utility system is the principal role of structural dynamics. This activity becomes more difficult as turbine configurations are revised to get "softer" to reduce loads. Frequency domain models are used to predict natural resonant frequencies and to tune the operating profile to avoid frequencies that are not well damped.Time domain models are more complicated, but are needed to represent the wind as a forcing function and the utility system as a host. Requested funding will provide for analysis of structural data from the cooperative research program. A major thrust is incorporation of turbulence and unsteady aerodynamics into models to improve predictions of stress and fatigue.

o Load Phasing and Fatigue Prediction

Fatigue life projections for wind turbines are subject to gross errors because current understanding of turbulence-induced loads is poor. While progress in rotationally sampled wind research has shown that turbulence on a scale of one blade chord length, rather than a rotor diameter, is significant, there is little understanding of the correlation of turbulence induced loads along a blade. This lack of information applies to both vertical and horizontal axis systems and is needed to improve structural loads models. Funding is requested to support pressure distribution and hot film anemometer testing on experimental and commercial horizontal axis turbines to provide data for improvements in models. Methods of fatigue prediction will also be compared.

ADVANCED COMPONENTS AND SUPPORTING RESEARCH

Advanced components and supporting research involves activities in two areas: advanced subsystems (e.g. airfoil, generators and control systems) and supporting research such as aeroacoustics, utility impacts and program planning.

In the advanced components area, efforts are focused on generic, proof-of-concept activities that make use of Federal research results, the most important of which is advanced airfoils. Most of the existing data on airfoils are on planforms that are intended for aircraft wing, propeller or helicopter rotor applications. Most of these designs are ineffective on wind turbines. This research effort will attempt to fill that gap. Similarly, the supporting research subelement cuts across turbine and disciplinary lines in providing program planning, environment impact studies, analysis of electrical problems associated with operating wind turbines in existing power grid systems, and other research which relates to generic applications of wind systems.

- Advanced Airfoils

Virtually all wind turbines to date have used aviation-oriented airfoils designed for a much more limited range of angles of attack and higher Reynolds numbers than characteristic of wind turbine operation. Recent wind tunnel results indicate that a 20-50 percent improvement in performance and desirable structural characteristics are possible by designing airfoils specifically for the wind turbine environment. Requested funding would continue development of families of horizontal and vertical axis wind turbine airfoils.

- Variable Speed Generation

The potential benefits of variable rotor speed operation are improved energy capture, reduced cyclic stresses, and improved control that offer significant improvement in wind turbine operation. Variable speed operation is considerably more complex than fixed rotor speed operation and industry lacks the necessary design tools at present. The DOE program is structured to develop this information to allow industry to evaluate alternative concepts. Requested funding will continue laboratory and field tests of various variable speed concepts.

- Supporting Research

The supporting research subelement includes planning and assessments, technology transfer activities, windfarm power quality, wind/diesel hybrid research and environmental studies on TVI and noise. Results from the general research program are applied in development of International Energy Agency Recommended Practices and in support of industry standards. Requested funding supports these private sector efforts and provides for systems and economic analyses, workshops and seminars, Historically Black College and Universities (HBCU) research activities and preparation of a wind turbine design handbook.

CAPITAL EQUIPMENT

The FY 1987 request for capital equipment of $170,000 will be used for research test equipment and data acquisition systems at selected laboratories.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Ocean Energy Systems	$4,811,000	$2,500,000	$-2,311,000

The oceans, covering 71 percent of the earth's surface, collect and store massive amounts of solar energy. Ocean Thermal Energy Conversion (OTEC) is a form of ocean energy which is renewable, capable of furnishing tens of quads per year, and available 24 hours a day, all year long. OTEC also has the potential to produce a variety of energy intensive by-products such as mariculture, fresh water and air conditioning while simultaneously producing energy. Wave energy, although not viewed as being as promising as OTEC in resource potential or availability, is attractive for its potential application to some geographical areas which do not have an OTEC resource. The FY 1987 budget request for Ocean Energy Systems is $2,500,000. This represents a decrease of $2,311,000 from the FY 1986 adjusted appropriation of $4,811,000.

The objective of the ocean energy program is to develop a generic technical data base and reduce the technical risks associated with the extraction and use of ocean derived energy sources to the point that allows industry to judge where and when the technology could be commercialized. DOE's strategy is to perform the necessary R&D required to develop a generic set of experimentally verified predictive models for industry's use. This approach is anticipated to furnish industry with a sufficiently credible data base and incentive to commericalize the ocean technologies, while making additional options available to decision makers in their formulation of a balanced energy supply.

Program emphasis in FY 1987 will be directed toward the "Experimental Verification and Testing" and "Thermodynamic Research and Analysis" segments of the FY 1986 effort. "Material and Structures Research" and "Oceanographic, Environmental and Geotechnical Research" studies have provided a data base available for implementation as integrated efforts within the two areas that are being carried forward and currently do not require the degree of emphasis that was necessary in past years.

EXPERIMENTAL VERTIFICATION AND TESTING

The objective of this program element is to provide a facility for private industry to conduct small-scale seawater tests and experiments which verify OTEC component functional feasibility, performance, and operational characteristics on a scale which can be extrapolated for use in modular systems applicable to small plants.

The FY 1987 budget will provide funds to upgrade the Seacoast Test Facility (SCTF) by expanding the capacity of its seawater systems. This upgrade was specified in the 1985 appropriation bill and is required to allow adequate access to the necessary quantities of warm and cold seawater resources needed to conduct the open-cycle OTEC research experiments. These experiments were also specified by previous appropriation bills, and include validation of components, subsystems and, eventually, a 150 kWe open-cycle test.

The following activity will be supported in FY 1987:

o Seacoast Test Facility Seawater Systems Upgrade

  - The objective of this activity is to provide adequate physical capability at the SCTF to support projected experimental research. This will be accomplished through an on-going 4-year effort to plan, fabricate and install a 30-inch diameter cold water pipe and necessary warm water and discharge pipes to upgrade the SCTF seawater systems. The final design of the installation was completed and long-lead items were procured in FY 1986. Installation of the associated on-shore systems will begin in FY 1987, with completion of the seawater pipe deployment and installation anticipated in FY 1988.

THERMODYNAMIC RESEARCH AND ANALYSIS

The objective of this program element is to experimentally determine the seawater and non-condensible gas effects on the open-cycle heat and mass transfer processes and to validate selected power system analytical models at a scale sufficient to extrapolate to small OTEC plant sizes. This research attempts to establish a generic understanding of how to design potentially cost effective open and latent-heat power systems which could meet the cost goals of the multi-year plan. Reaching these goals is dependent upon increasing the output of the power system and significantly reducing the life cycle cost. Cost reduction for small OTEC plants in the 5 to 15 MWe range is viewed as critical to motivating industrial investment for commerical-ization of the OTEC technology.

The following activities will be supported in FY 1987:

- Heat and Mass Transfer Analysis and Model Validation
    - This task involves the validation of analytical models for open-cycle OTEC evaporation, condensation and seawater/air sorption processes. During FY 1987, the results from FY 1986 heat and mass transfer experiments will be evaluated. Freshwater laboratory experiments to identify transfer coefficients will be completed and these results will be correlated to seawater engineering data. Process coupling between heat and mass transfer and thermal conversion systems will be modeled and analyzed in this activity. The planning and coordination of the open-cycle program will be accomplished within this activity.
- Advanced Theory for Open-Cycle OTEC Systems Process Integration
    - The objective of this activity is the development of thermodynamic and economic models for open-cycle OTEC systems. In FY 1987, results from fresh water heat and mass transfer experiments conducted in FY 1986 will be incorporated into the open-cycle System Analysis Language Translater (SALT) model to improve the cost algorithms. This task will provide the basis for refining follow-on experiments being performed in FY 1987. The completed product will be an experimentally verified computer model to be used by industry to conduct technology assessments.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
International Solar Energy Program.....	$962,000	$500,000	$462,000

The FY 1987 budget request for Solar International is $500,000, which is a $462,000 reduction from the FY 1986 adjusted appropriation of $962,000.

The Renewable Energy Industry Development Act (P.L. 98-370) passed in 1984 requires that the Federal Government play a catalytic role in promoting U.S. developed renewable energy technology within the competitive international marketplace. The DOE chairs the Committee on Renewable Energy Commerce and Trade (CORECT) and the Renewable Energy program has the lead role for the technical competitiveness subcommittee of this inter-agency working group. Funds will be used to prepare necessary reports and information for use by Federal organizations and industry.

Additionally, budgeted funds are used to conduct a program managed by the trade experts in the Department of Commerce-International Trade Administration (ITA), with broad managerial and technical assistance provided by DOE and the Renewable Energy Export Council, a coordinating body for private sector participants. This Commerce agency cost-shares with U.S. firms the development and presentation of exhibitions, special trade missions, trade seminars and video catalog shows. The FY 1987 funding will provide for a DOE-ITA international trade promotion program with a continuing focus on the international markets of more significant potential.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Solar Technology Transfer............	$2,938,000	$1,950,000	$1,033,000

The FY 1987 Solar Technology Transfer budget request of $1,950,000 represents a $983,000 reduction from the FY 1986 adjusted appropriation of $2,938,000.

The objective of the program is to continue mainline technical and public informtion services in a low-visibility reactive mode of operations. New funds are requested for the purchase of computer capital equipment for word processing in order to facilitate improved production efficiencies.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Solar Energy Research Institute......	$2,244,000	$545,000	$1,699,000

General Plant Projects - A total of $230,000 is being requested for general purpose capital improvements to the permanent DOE facilities at the Solar Energy Research Institute (SERI). The improvements proposed are the fabrication of a chemical waste neutralization and/or recycling facility, a combustible gas handling system, and general repairs such as repair and maintenance of tertiary roads, plus fire safety improvements.

General Purpose Equipment - A total of $315,000 is being requested for general purpose equipment for the permanent DOE facilities at SERI. Funds are to be used to improve the efficiency and use of the facility. The actions consist of procuring a remote job entry (RJE) station with tape drive, an IBM 3031 upgrade, a high-speed printer, expansion of the toxic gas monitoring system, a HNU photoionizer with three probes, an upgrade of the radio communications system, and an explosion-proof forklift.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Solar Program Support...............	$1,251,000	$897,000	$354,000

The FY 1987 budget request for Solar Program Support is $897,000, which is a $354,000 reduction from the FY 1986 adjusted appropriation of $1,251,000.

The purpose of this budget item is to provide cross-technology analytical and administrative support to the overall solar/renewable energy research effort.

Technical and administrative assistance is required to minimize requirements for permanent FTE's and to perform short term analyses more suited to contracted analysis. Fixed operating charges for computer and telecommunication equipment usage will also be funded to promote management efficiencies.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Solar Resource Assessment............	$962,000	$700,000	$262,000

The FY 1987 budget request for Solar Resource Assessment is $700,000, which is a $262,000 reduction from the FY 1986 adjusted appropriation.

The variability of the solar resource within regions requires greater definition in order to provide the basis for understanding the complex interactions involved in solar technology efficiency and reliability. Activities to improve the overall understanding of resource variability will be continued in order to provide scientific and technical data to researchers and industry participants.

Information regarding the distribution, spectral and temporal variability of solar energy resources is critical for designing appropriate experiments, and for interpolating laboratory and field results. In some instances, the knowledge base appears to be limited and inadequate to postulate and evaluate advanced theories.

For FY 1987, activities will continue for resource measurement and modelling, algorithm development, and the research of new methodoloiges. Projects will continue to be jointly selected by DOE Solar Energy managers, and representatives from other Federal agencies, universities and industry.

	Adjusted FY 1986 Approp.	FY 1987 Request	Net Change
Solar Program Direction...........	$4,516,000	$4,100,000	$416,000

The FY 1987 budget request for Solar Energy Program Direction of $4,100,000 will support a full-time equivalent (FTE) staffing level of 70. This proposal is a $416,000 reduction from the FY 1986 adjusted appropriation and a reduction of 18 FTEs.

The Federal Solar Energy staff activities consist of three major functions; project/task management, R&D coordination/technology transfer, program and general administration duties. A wide variety of professional and clerical skills are necessary to administer R&D relating to several innovative technologies, and cross-cutting functional activities.

DEPARTMENT OF ENERGY

FY 1987 CONGRESSIONAL BUDGET REQUEST

PROGRAM OVERVIEW

GEOTHERMAL

The Geothermal Energy Program continues to play a major role in building a technology base to enable the private sector to economically develop the various forms of geothermal resources. Through this effort the Geothermal Program provides an array of technology options that expand and strengthen the energy supply mix from which industry can draw in developing products and processes for commercial applications.

Accordingly, the program places an increased emphasis on R&D activities which are cost-shared with the private sector and that provide the appropriate stimulus and support for development. These activities primarily focus on basic and applied research, technology development, technical assistance and information activities. By employing strategies which couple federally funded basic and applied research and development efforts with timely technology transfer, security and flexibility in the energy marketplace is enhanced.

In addition, a new innovative approach to cooperative R&D ventures with the private sector will be closely examined. Through appropriate dialogue with industry, the framework for joint partnership between Government and industry cooperative ventures, which will effectively broaden research support and technology transfer, can be established and if successful will significantly lower the Federal expenditures.

Prior Year Accomplishments:

- o Developed new geophysical survey methods and equipment for the acquisition and field analysis of seismic and electromagnetic signals from the earth. The geothermal industry has adopted these methods as standards. Development of 2- and 3-dimensional methods for interpretation of geophysical data have had an immediate impact on industry exploration.
- o Research in geothermal brine injection has shown that chemical and physical changes to the reservoir caused by production can be predicted, and through injection management, reservoir problems can be avoided. Initiated development of fluorocarbons for tracer usage; completed analysis of drift phenomena in injection backflow data; initiated experimental testing of conventional tracers and initiated modeling and field testing of borehole resistivity. Industry is using the products of this research to lengthen the useful life of geothermal fields.
- o Initiated activities to develop an advanced drill bit using a hybrid system wit polycrystalline diamond cutters and water jets; completed electrical design of improved acoustic borehole televiewer; and laboratory tested DOE/industry cooperative drilling equipment.
- o Completed laboratory studies on pitting-resistant steel used as cladding for well casings; and tested advanced materials and instruments in the laboratory and field.

- Initiated leaching tests to determine technical feasibility of waste encapsulation while meeting environmental regulations; initiated experiments to determine technical feasibility for decontaminating waste fluids from heavy metals using biochemical methods on geothermal waste.

- Completed isobutane supercritical cycle thermal loop tests; completed vertical-condenser thermal and power-loop testing with isobutane-hexane mixtures as working fluids. This greatly expanded the temperature range over which binary geothermal plants could operate.

- Operated the Geothermal Test Facility in support of heat-cycle research, and performed tests of industry material and equipment.

- Drilled the Salton Sea scientific borehole in a hot hydrothermal reservoir near a magma body and initiated engineering evaluations and resource studies related to the deep scientific hole to test the premise that geothermal resources are larger than presently estimated; studied thermal gradient and other geophysical measures to develop techniques for evaluating geothermal resources masked by deep-flowing rainwater.

- Completed preliminary analysis of magma energy conversion concepts and systems economics, performed seismic survey for probable magma chamber, and tested selected materials for compatibility with magma environment.

- Synchronized, in June, 1985 the main power turbine-generator of the Heber Binary Power Plant (i.e., made compatible with the frequency requirements of the transmission system), following initial turbine tests. After careful shakedown experiments, the complete power plant continued partial power tests in 1986.

- Flow testing at high rates resulted in scale accumulation in a geopressured production well. Chemicals were injected into the producing formation in a test of a new scale control technique. Subsequently, the well was flowed at high rates for extended periods of time without scaling.

- As the result of redrilling one of the two Hot Dry Rock wells, successfully connected the large fracture zone produced from the lower well in 1985 to form a below-ground heat transfer circuit. Initial heat removal experiments were carried out while equipment was designed and constructed for extended heat removal experiments during FY 1986; in addition, the below-ground flow pattern was modified to improve the system hydrodynamics.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
GEOTHERMAL
ENERGY SUPPLY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars)

	FY 1985 Appropriation	FY 1986 Adjusted Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Geothermal Energy					
Operating Expenses	$29,298	$26,200	$26,200	$17,930	-$ 8,270
Capital Equipment	$ 400	$ 481	$ 481	$ 0	-$ 481
	$29,698	$26,681	$26,681	$17,930	-$ 8,751
Staffing					
Total FTE	12	15	15	12	(3)

Authorization: P.L. 93-410 Geothermal Energy Research, Development and Demonstration Act of 1974.

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	General Reduction	Gramm-Rudman-Hollings Reduction	Subtotal	Comparability Adjustments	Adj. Approp. Total
Geothermal (CE)									
Hydrothermal Industrialization									
Operating Expenses	$ 2,000	$ ---	$ -400	$ -203	$ ---	$ -75	$ 1,322	$ 203	$ 1,525
Geopressured Resources									
Operating Expenses	4,600	---	---	-5	---	-174	4,421	5	4,426
Geothermal Technology Development									
Hot Dry Rock Research	5,500	---	---	---	---	-752	4,748	---	4,748
Hydrothermal Research									
Operating Expenses	$ 8,000	$ ---	$ ---	$ -1	$ ---	$ ---	$ 7,999	$ 1	$ 8,000
Capital Equipment	200	---	---	---	---	-8	192	---	192
Subtotal	$ 8,200	$ ---	$ ---	$ -1	$ ---	$ -8	$ 8,191	$ 1	$ 8,192
Hard Rock Penetration Research									
Operating Expenses	$ 2,400	$ ---	$ ---	$ ---	$ ---	$ ---	$ 2,400	$ ---	$ 2,400
Capital Equipment	200	---	---	---	---	-8	192	---	192
Subtotal	$ 2,600	$ ---	$ ---	$ ---	$ ---	$ -8	$ 2,592	$ ---	$ 2,592
Magma Energy Extraction Research									
Operating Expenses	$ 4,400	$ ---	$ ---	$ ---	$ ---	$ ---	$ 4,400	$ ---	$ 4,400
Capital Equipment	100	---	---	---	---	-3	97	---	97
Subtotal	$ 4,500	$ ---	$ ---	$ ---	$ ---	$ -3	$ 4,497	$ ---	$ 4,497
Total, Geothermal Technology Development	$27,400	$ ---	$ -400	$ -209	$ ---	$-1,020	$25,771	$ 209	$25,980
Program Direction	800	-56	---	-70	-14	-29	631	70	701
Subtotal, Geothermal	$28,200	$ -56	$ -400	$ -279	$ -14	$-1,049	$26,402	$ 279	$26,681
General Reduction:									
Operating Expenses	-56	56	---	---	---	---	---	---	---
Management Initiatives:									
Operating Expenses	-400	---	400	---	---	---	---	---	---
F.E Reduction	-14	---	---	---	14	---	---	---	---
Pay Restoration	-279	---	---	279	---	---	---	---	---
Use of Prior Year Balances (Geothermal)									
Operating Expenses	279	---	---	---	---	---	279	-279	
Total, Geothermal	$27,730	$ ---	$ ---	$ ---	$ ---	$-1,049	$26,681	$ ---	$26,681
Operating Expenses	$27,230	$ ---	$ ---	$ ---	$ ---	$-1,030	$26,200	$ ---	$26,200
Capital Equipment	500	---	---	---	---	-19	481	---	481

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES

GEOTHERMAL

(Dollars in Thousands)

FY 1986 Appropriation adjusted	$26,681
Program increases and decreases:	
o Geothermal R&D Operating Expenses	-$ 8,270
o Capital Equipment	-$ 481
FY 1987 Budget Request	$17,930

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
GEOTHERMAL ENERGY NARRATIVE

	FY 1986 Adjusted Approp.	FY 1987 Request	Net Change
Geothermal	$26,681,000	$17,930,000	-$8,751,000

The objective of the Geothermal R&D program is to sponsor research which will facilitate the expanded use by industry of the large, underutilized resource represented by the various forms of geothermal energy. Cooperation with industry is vital to an effective program, and on-going efforts such as cost-shared electricity generation experiments with geopressured resources will be expanded. The program includes research on hydrothermal reservoirs, energy conversion technology, improved hard rock penetration technologies, and advanced technology for the extraction of energy from geopressured, hot dry rock, and magma geothermal resources. Also included is funding for program direction, to manage a broad range of geothermal research and development. The FY 1987 Departmental Request for Geothermal is $17,930,000, which is a $8,751,000 reduction from the FY 1986 adjusted appropriation of $26,681,000.

	FY 1986 Adjusted Approp.	FY 1987 Request	Net Change
Hydrothermal Industrialization	$ 1,525,000	$ 0	-$ 1,525,000

No funds are being requested in FY 1987. The assessment of hydrothermal energy resources on a state basis has progressed to a stage where individual states have the capability to continue these activities as required.

	FY 1986 Adjusted Approp.	FY 1987 Request	Net Change
Geopressured Resources	$ 4,426,000	$ 3,000,000	-$ 1,426,000

The objective of the geopressured resource program is to define the extent and energy content of the geopressured resource and to determine significant technical parameters for extracting and using chemical, thermal, and mechanical energies contained in the geopressured brines. Geopressured brine and natural gas occur worldwide, but are especially well documented beneath the U.S. Gulf of Mexico coast, where the U.S. Geological Survey (U.S.G.S) estimates there are over 60,000 Quads of thermal energy and 50,000 Quads of dissolved methane in place. Prior research under this program has established the magnitude of the resource base, and has shown that the brine can be produced, the methane recovered, and the spent brine injected. But the capacity for extended production at high flow rates has not yet been established. In addition there are the problems related to scaling in wells and the possibility of land subsidence. The proposed research in FY 1987 will address the uncertainties in reservoir longevity and provide technical data that industry can exploit to determine the role of this vast domestic resource in future energy markets.

FY 1987 funds will be used to conduct experimental production testing of wells especially designed and drilled for this research. The wells produce hot brine that contains dissolved natural gas. High pressure in the underground reservoirs causes the brine to flow freely, without pumping, through wells. These multi-year tests, at flow rates in the millions of gallons per day range, will reveal the dynamic characteristics of the underground reservoirs of brine and gas. At the wellhead, natural gas is readily separated from the brine. In cooperation with industry, tests are being conducted on systems that convert the thermal and chemical energy content of the brine to electric power. Scaling control methods, developed in cooperation with industry, also will be tested.

Supporting research will include: chemical analysis of the produced brines and hydrocarbons; analysis of brine pressure, temperature and flow rates to infer underground reservoir rock conditions; scale control research; and investigation of environmental effects, especially land subsidence.

	FY 1986 Adjusted Approp.	FY 1987 Request	Net Change
Geothermal Technology Development....................	$20,029,000	$14,150,000	-$5,879,000

There are four geothermal technology development activities included under the Departmental Request: hydrothermal research, hard rock penetration research, magma energy extraction research, and hot dry rock research.

- Hydrothermal Research

  The objective of this activity is to perform research on geothermal reservoirs and energy conversion systems in order to expand the hydrothermal resource base available for development by the private sector. Additional emphasis will be directed toward research on second generation binary systems that will make possible utilization of widespread moderate temperature hydrothermal resources. Royalties from power generated on Federal land already exceed the funding level for DOE hydrothermal research, and these Government revenues are expected to increase greatly as the advancing technology base provides industry with the opportunity to exploit more of the resource. New methodology is being developed to locate and penetrate fractures, the main permeable channels for fluid flow in the reservoir. Instruments and materials will enable industry to evaluate the resource and to produce the energy with the least delay. Large gains in conversion efficiency are obtainable if reliability can be improved. New methods for locating and evaluating the potential resource in selected areas are being tested for applications to this and similar systems.

  FY 1987 research will be conducted in the following areas: reservoir definition technology, brine injection technology, materials research, advanced brine chemistry, heat cycle research, Geothermal Test Facility operations, Salton Sea and Continental Scientific Drilling Projects, and Caldera reservoir investigations.

  - Reservoir Definition Technology: The objective of this task is to improve the technologies needed to locate, delineate, characterize, and control hydrothermal reservoirs. An improved understanding of geothermal reservoirs will allow private industry to efficiently utilize this energy resource. This task will cover that part of the research which is generic and cannot be accomplished solely by the geothermal industry. Joint research projects with industry participation will be used to advance the technology.

FY 1987 funds will be applied to reservoir studies to determine the location and extent of fractures, the physical and chemical properties of fluid flow, and the most efficient methods of production from the reservoir. Models will be developed and tested with field data to correlate the actual data with model predictions.

- Brine Injection Technology: The objective of this task is development of technology for the economic injection of spent brines into geothermal reservoir formations in order to recharge the reservoir, dispose of the brine, and minimize subsidence. Previous research has shown that injection is necessary to obtain the optimum energy production and longevity from geothermal reservoirs. Several parameters such as location of production and injection wells, flow rates of the wells, and chemistry of injected brine can be adjusted to provide the maximum energy recovery. This task will conduct the research necessary to understand the control of these parameters.

  FY 1987 funds will be used to conduct cost-shared field studies and analysis involving interference pressure tests and tracer test in order to determine the best methodology for location and operation of injection wells; to develop predictive methods for anticipating pressure, chemical, and thermal pulses from injection to production wells; and to develop methods for establishing the rate of chemical precipitation around injection wells.

- Materials Research: The objective of this task is the development of geothermal systems that are capable of resisting highly hostile geothermal environments for prolonged periods of time, thereby increasing equipment life and reliability and reducing the cost of fluid handling. Cost-sharing with industry will continue in this area.

  FY 1987 funds will be used to perform research on metal liners for well casing, polymer concrete composites for heat exchanger tubing, and high temperature cements.

- Advanced Brine Chemistry: The objective of this task is to provide the research necessary to evaluate advanced processing technology for safe disposition of hypersaline geothermal brines. Previous research has shown that geothermal brines contain significant quantities of several metals. These metals represent hazardous waste that must be disposed of, thus increasing the cost of geothermal operations.

  FY 1987 funds will be used to investigate extraction processes that can be used with geothermal brines and solid residues to reduce the hazard of geothermal wastes. In addition, technology will be developed to measure key chemical constituents in process and energy conversion systems.

- Heat Cycle Research: The objective of this task is the development of technology for the economic generation of electricity from moderate temperature hydrothermal resources. These resources are four times as numerous as the high-temperature resources which are currently exploitable with first generation energy conversion technology. If the moderate temperature reservoirs are to be utilized, a new generation of more efficient, reliable, and less costly binary technology must be developed.

  FY 1987 funds will be used to test supersaturated hydrocarbon turbine expansions and to investigate methods of improving direct contact heat exchangers for high salinity brines in order to increase the efficiency of the conversion of geothermal energy.

- Geothermal Test Facility: The objective of the test facility is to provide a field site for testing of geothermal energy conversion systems of interest to industry, in an actual geothermal environment.

  FY 1987 funds will be used to operate the DOE Geothermal Test Facility which will be used for industry and DOE field testing activities. The facility contains geothermal wells and brine handling equipment, test pads, workshops, offices, and a chemistry laboratory.

- Salton Sea Scientific Drilling Project: The objective of this research is to determine the nature of potential reservoirs that underlie a known high-temperature hydrothermal reservoir, in order to better understand the genesis and structure of hydrothermal resources and to assess theories that the nation's hydrothermal resources are far larger than previously estimated. Further, this task will provide the technology and the new and improved materials, tools, equipment, and instrumentation that will be required to conduct drilling, testing, measuring and sampling operations in the hostile environments expected to be encountered in continued scientific drilling into deep thermal regimes. This project is an integral part of the Federal Continental Scientific Drilling Program coordinated between DOE, USGS and NSF. Results of this task when combined with the larger effort of the other agencies, increases the benefit to the geothermal energy program by a very large factor.

  The FY 1987 funds will be used to conduct resource studies, and synthesize results of all the engineering and chemical analysis and instrument testing related to the scientific drilling, testing, and measuring in deep, hot reservoirs containing highly corrosive but potentially valuable brines.

  The funds will also be used to develop, in cooperation with industry, new drilling and casing systems and downhole materials, instruments and sampling techniques.

- Caldera Reservoir Investigations: The objective of this task is to conduct research on techniques for investigating the nature of hydrothermal reservoirs associated with young andesite volcanoes. In such areas the geothermal reservoirs are masked by shallower, cooler aquifers and lower vertical permeability so that thermal gradient measurements and other scientific measurements only begin to characterize the reservoirs at greater depths. Geophysical measurements combined with wells designed for maximum scientific return will be used to perform this research.

  FY 1987 funds will be used to analyze and interpret the drilling, geophysics and geology results gained from prior year testing and measuring of several deep thermal gradient research boreholes. The boreholes were developed to carry out research and tests of new system sensing and evaluation techniques to study young volcanic fields. The project is being cost-shared with industry under cooperative agreements.

o Hard Rock Penetration Research

Geothermal wells represent forty to sixty percent of the cost of geothermal electric power and an even larger fraction of the cost of many direct heat applications. Although geothermal wells are drilled and completed using technology adapted and evolved from oil and gas well drilling, the hot, hard crystalline rock and corrosive environment cause such a rapid degradation of the drilling equipment that geothermal well costs are considerably higher than the costs of similar oil and gas wells by a factor of two to four.

The purpose of research under this activity is to increase the portion of the geothermal resource which is currently exploitable by reducing the technological risks associated with drilling and completing geothermal wells; by investigating new concepts, in cooperation with industry, that show promise for incorporation into second generation geothermal drilling systems; and by performing research in promising technical areas such as advanced alloys, new physical processes, and new design concepts.

In FY 1987, research tasks will be conducted in the following areas:

- Advanced Drilling Research: The objective of this task is to evaluate selected advanced candidate methods for breaking and removal of rock, which have the potential for development into advanced drilling systems.

  FY 1987 funds will be used to perform research, jointly with industry, on several revolutionary drilling concepts. These will include a hybrid drill bit with high pressure jet-assisted cutters; a thruster/retractor for applying weight-on-bit when drilling with downhole motors; downhole measurement, data processing, and control while drilling; and spoolable drill pipe.

- Mechanics of Rock Penetration: The objective of this task is to analyze cavitating jets and drill string dynamics and to measure the parameters associated with rock penetration by methods such as crushing, spalling, shearing, erosion and shock loading under simulated geothermal downwell conditions.

  In FY 1987, the interaction between geothermal formation and drill bit cutters will be studied in laboratory experiments and computer simulations to determine and characterize the critical formation and drilling system properties which control the process of rock penetration. The studies will include rock mechanics as well as the behavior of drill bit cutters, and the influence of various types of drilling fluids.

- Drilling Fluid Loss Control: The objective of this task is to develop new effective materials for controlling the loss of drilling fluids into fractures or aquifers encountered during drilling and completion in high temperature environments. Loss of drilling fluid is one of the most serious problems in geothermal well drilling today since the drilling process must be halted until the situation is corrected; often, the formation can be damaged permanently by excess fluid loss.

  FY 1987 funds will be used to evaluate, in cooperation with industry, new fluid loss materials for preventing and controlling lost circulation in geothermal wells, and to develop computer models to understand the flow near a lost circulation zone to permit the design of remedial methods which correctly address the problem.

o Magma Energy Extraction

The objective of this activity is to understand and evaluate the energy potential contained in the magma resources of the United States. Through this research effort, the knowledge necessary to use this potentially large energy source will be gained. New materials are being developed to withstand the high-temperature (1000°C) corrosive magma environment, and instruments are being designed to monitor drilling and extraction conditions. Incomplete data exists on the depth and size of continental magma chambers. Estimates must be refined based on field and experimental laboratory data, and extrapolations of technology capability must be made and used for an update of the potential of United States magma resources to help supply energy in the future.

The FY 1987 funds will be used to determine the technological potential of magma energy and the advantages of different energy conversion methods and heat extraction processes. Research on materials, equipment, and instrumentation for the high-temperature, hostile environment of magma will continue. In addition, estimates of the depth, size, and temperature of prospective magma chambers will be refined, based on continued data gathering, analysis and interpretation.

o Hot Dry Rock Research

The objective of Hot Dry Rock (HDR) research is to study the fundamental properties of deep hot crystalline rock systems and, based on those findings, determine the technical boundaries and economic feasibility of extracting geothermal heat from hot dry rock resources. The USGS has estimated that in the U.S. as much as 450,000 Quads of potential energy exists in hot dry rock. However, before this vast resource can be expected to be used, it is necessary to develop the science and technology necessary to extract that energy. As part of the Hot Dry Rock project, proof-of-concept experiments were completed in 1980 with a single-fracture thermal loop, and two wells have since been successfully drilled into hot crystalline rock and connected in 1985 through a large reservoir created by a massive hydraulic fracture. Under current plans the loop will be tested to determine system characteristics such as (1) flow control through a multi-fractured system; (2) predicted thermal drawdown and reservoir longevity; (3) reservoir hydrodynamics; (4) changes in system flow impedance; (5) rock-fluid interaction; and (6) environmental effects. It is expected that these tests will be completed by FY 1989. These system characteristics are parameters which must be understood before private sector development can be expected. The preparation and testing of this loop is covered by an International Energy Agency cooperative agreement, and both West Germany and Japan have made important financial and scientific contributions to the project. Their support has been one of the major factors in the experimental progress to date.

FY 1987 funds will be used to complete the assembly and begin the extended testing of a circulation loop and heat exchanger system. This system is a critical part of a reservoir evaluation experiment to determine the characteristics of the large hydraulically-fractured reservoir. Energy capacity studies of the hot crystalline rock containing interconnected flow channels will also be carried out.

Supporting research studies include an evaluation of alternative flow control systems, the use of chemically reactive tracers to map time-temperature flow channels, and the analysis of seismic signals to detect tensile as well as shear fracturing events.

	FY 1986 Adjusted Approp.	FY 1987 Request	Net Change
o Program Direction...............	$ 701,000	$ 780,000	+$ 79,000

The budget request supports 12 FTEs. This includes administrative and technical personnel who manage a broad range of geothermal research and development activities.

Personnel assigned to Headquarters will perform a number of responsibilities including the establishment of broad objectives, determination of work scope, allocation of general resources, and technical management necessary for program direction. Responsibilities will also include the assessment of progress made in meeting DOE technical milestones and cost expenditures, coordination of contractor activities, and initiation of appropriate actions to resolve problems in any of these areas. Further, responsibilities will include administrative and functional activities such as budgeting, procurement, long and short range program planning and personnel management activities. In addition, personnel will be required to interface with a number of other Federal agencies (such as DOD, NASA, NBS, and DOI), national laboratories, industrial concerns, and international bodies in order to execute and coordinate programs of mutual interest.

In addition to activities proposed for funding for FY 1987, research and industrialization projects which were initiated in prior years will be completed during this same period.

DEPARTMENT OF ENERGY
FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST
ENERGY CONSERVATION
VOLUME 7
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DEPARTMENT OF ENERGY

Proposed Appropriation Language

Energy Conservation

For necessary expenses in carrying out energy conservation activities, [$449,418,000] $39,433,000, to remain available until expended: Provided, That [pursuant to section 111(b)(1)(B) of the Energy Reorganization Act of 1974, as amended, 42 U.S.C. 5821(b)(1)(B), of the amount appropriated under this head, $10,319,000 shall be available] of the amounts appropriated under this head in Public Law 99-190, funds available for a grant for basic industry research facilities located at Northwestern University [without section 111(b)(2) of such Act being applicable: Provided further, That section 404 of Public Law 98-558 shall not be effective in any fiscal year in which the amount made available for low income weatherization assistance from appropriations under this head is less than 5 per centum above the amount made available in fiscal year 1985: Provided further, That $7,500,000 of the amount provided under this heading shall be available for a research and development initiative with the national laboratories for new technologies up to proof-of-concept testing to increase significantly the energy efficiency of processes that produce steel: Provided further, That obligation of funds for these activities shall be contingent on an agreement to provide cash or in-kind contributions to the initiative or to other collaborative research and development activities related to the purpose of the initiative equal to 30 percent of the amount of Federal government obligations. Provided further, That existing facilities, equipment, and supplies, or previously expended research or development funds are not acceptable as contributions for the purposed of this appropriation, except as amortized, depreciated, or expensed in normal business practice: Provided, further, That the total Federal expenditure under this proviso shall be repaid up to one and one-half times from the proceeds of the commercial sale, lease, manufacture, or use of technologies developed under this proviso, at a rate of one-fourth of all net proceeds] and funds available for a research and development initiative with the national laboratories for energy-efficient steel production technologies shall be available for other expenses of energy conservation activities. (Department of the Interior and Related Agencies Appropriations Act, 1986, as included in Public Law 99-190.)

ADDITIONAL ADMINISTRATIVE PROVISION -- DEPARTMENT OF ENERGY

Any statutory provisions requiring the maintenance of full-time permanent Federal employees, or prohibiting actions to reduce employment levels, or otherwise establishing requirements for personnel levels of the Department of Energy or any of its offices or activities, are hereby repealed.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

ENERGY CONSERVATION

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
Transportation	61,341	56,637	19,800
Industrial	31,706	40,096	15,623
Buildings and Community Systems	41,025	37,280	14,150
Multi-Sector	23,791	25,574	19,850
Facilities	15,681	9,608	---
Subtotal, Conservation R&D	173,544	169,195	69,423
State and Local	283,400	256,630	5,000
Policy and Management	1,747	1,687	1,792
Policy Analysis	245	---	---
Subtotal, Energy Conservation	458,936	427,512	76,215
Use of Prior Year Balances	-1,500	---	---
Use of FY 86 Deferral-(CE)EC	---	---	-36,782
Total, Energy Conservation	$457,436	$427,512	$ 39,433

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Approp.	FY 1986 Approp.	FY 1987 Base	FY 1987 Request	Request vs Base
Buildings and Community Systems					
Operating Expenses:					
R&D Activities	36,905	31,860	31,860	11,750	(20,110)
Program Direction	2,895	3,557	3,557	2,400	(1,157)
Subtotal Operating	39,800	35,417	35,417	14,150	(21,267)
Capital Equipment	1,225	1,863	1,863	0	(1,863)
Total Buildings and Community Systems	41,025	37,280	37,280	14,150	(23,130)
Staffing, FTEs	57	71	71	45	(26)
Industrial Energy Conservation					
Operating Expenses:					
R&D Activities	27,743	38,080	38,080	13,779	(24,301)
Program Direction	1,807	2,016	2,016	1,844	(172)
Subtotal Operating	29,550	40,096	40,096	15,623	(24,473)
Capital Equipment	2,156	0	0	0	0
Total Industrial Energy Conservation	31,706	40,096	40,096	15,623	(24,473)
Staffing, FTEs	33	35	35	26	(9)
Transportation					
Operating Expenses:					
R&D Activities	56,488	51,693	51,693	18,400	(33,293)
Program Direction	1,913	2,140	2,140	1,400	(740)
Subtotal Operating	58,401	53,833	53,833	19,800	(34,033)
Capital Equipment	2,940	0	0	0	0
Plant	0	2,804	2,804	0	(2,804)
Subtotal Plant & Capital Equipment	2,940	2,804	2,804	0	(2,804)
Total Transportation	61,341	56,637	56,637	19,800	(36,837)
Staffing, FTEs	33	36	36	22	(14)

	FY 1985 Approp.	FY 1986 Approp.	FY 1987 Base	FY 1987 Request	Request vs Base
Multi-Sector					
Operating Expenses:					
R&D Activities	21,833	24,146	24,146	19,250	(4,896)
Program Direction	292	498	498	500	2
Subtotal Operating	22,125	24,644	24,644	19,750	(4,894)
Capital Equipment	1,666	930	930	100	(830)
Total Multi-Sector	23,791	25,574	25,574	19,850	(5,724)
Staffing, FTEs	4	9	9	8	(1)
State and Local					
Operating Expenses:					
Grants/Program Activities	273,439	247,105	247,105	0	(247,105)
Program Direction	9,961	9,525	9,525	5,000	(4,525)
Total State and Local	283,400	256,630	256,630	5,000	(251,630)
Staffing, FTEs	178	180	180	100	(80)
Policy and Management					
Operating Expenses	1,747	1,687	1,687	1,792	105
Staffing, FTEs	28	21	21	17	(4)
Policy Analysis					
Operating Expenses	245	0	0	0	0
Facilities					
Plant	15,681	9,608	9,608	0	(9,608)
Operating Expenses	435,268	412,307	412,307	76,115	(336,192)
Capital Equipment	7,987	2,793	2,793	100	(2,693)
Plant	15,681	12,412	12,412	0	(12,412)
Total Energy Conservation	458,936	427,512	427,512	76,215	(351,297)
Total FTEs	333	352	352	218	(134)

FY 1987 Congressional Budget
MAJOR ACTIVITY OVERVIEW
Energy Conservation

Energy conservation continues to play an important role in improving the nation's energy and economic efficiency. Conservation has come chiefly from increased efficency in the use of energy and from a shift in the Nation's mix of goods and services towards less energy intensiveness. Between 1973 and 1984, the amount of energy required to produce a constant dollar of gross national product declined by 24 percent; for the last two years alone there was a five percent improvement. Total energy consumption in 1984 was actually less than in 1973, and far below what would have been projected had pre-1973 trends continued. The decline among certain energy-intensive industries, played a role in reducing energy consumption during this 10-year period, but improvements in energy efficiency alone are estimated to account for more than 29 quads of cumulative energy savings since 1973.

The residential sector has shown a very sharp decrease in energy use per household compared with earlier habits and trends, contributing almost 40 percent to the 29-quad total savings achieved by the overall economy in comparison with pre-1973 trends. Better insulated houses, improved appliance efficiency, and changes in household behavior have helped.

Within the industrial sector, improvements in energy efficiency account for approximately 30 percent of the economy-wide savings. Improved industry practices and changes in the industrial production mix have both been major contributors, with the former providing most of the gain.

The commercial sector has contributed about 20 percent of the 29-quad savings through improvements in building design, lighting, refrigeration, energy storage, and computerized management of energy use.

In the transportation sector, increased auto and truck efficiency has been coupled with improved airline technical and operating efficiency to reduce energy used per mile of passenger or freight movement. This contributed the final 10 percent to the total savings, as compared to pre-1973 trends.

Because it takes time for proven conservation technologies to be adopted by both sellers and buyers, we have not yet by any means seen the total impact of conservation decisions made following the oil disruptions of the 1970's.

There are strong reasons to expect continued improvements in energy use efficiency. Conservation actions by industry often are tied directly to efforts to improve productivity and competitiveness. Even at today's lower energy prices, many more cost-effective improvements remain to be made in new cars, homes, commercial buildings, and industrial equipment. The continuing development and introduction of new technology will increase the efficiency of performance and broaden the range of conservation options available in the marketplace.

While efficiency continues to improve, total U.S. energy consumption rose during 1984 for the first time in 5 years. This increase, to 74 quads, represents a rise of about 4 percent from 1983 levels. This increase is attributed, in part, to the Nation's increasing economic growth, which expanded to 7 percent in 1984, and to declining prices, which made conservation actions seem less economically attractive and softened attitudes towards the benefits of conservation. This rise in total energy consumption serves as a reminder that conservation must continue to play a prominent role in national energy policy to ensure the Nation's long-term energy security and economic well-being.

Many important opportunities remain to reduce future energy demands cost-effectively through innovation and the introduction and commercial application of advanced, highly efficient, energy-related technologies. A doubling of our efficiency gains over the past decade (in percentage terms) is probably economically feasible by the year 2010, even if current energy prices remain stable or experience a moderate decline. This will not require large government outlays. As conservation takes hold, it does so by being the most cost-effective of all energy options in a great variety of circumstances within all energy consuming sectors.

The Energy Conservation section of the Congressional Budget includes two major program areas, Conservation Research and Development and the State and Local Assistance Programs.

MISSION AND OBJECTIVES OF ENERGY CONSERVATION RESEARCH AND DEVELOPMENT

The mission of the Conservation Research and Development Program is to encourage the full development of energy conservation's potential and to provide a robust array of technology options for that will strengthen the technology base on which industry can draw in developing future new products and processes for the commercial market.

Accordingly, the program carries out a broad range of activities, each designed to contribute in a significant way to the technical and economic environment necessary to support this development. These activities focus primarily on basic and applied research, technology development, technical assistance, and information activities. They also include energy management within the federal establishment, and the development of guidelines and standards where required by law.

The objectives of the R&D activities are to: (1) improve the efficiency by which resources are used in the economy, focusing on energy (and thereby improving the competitiveness of energy-intensive industries); (2) increase the flexibility and diversity of available energy end-use technologies, focusing in particular on alternatives to those currently based exclusively on one form of energy, such as petroleum in transportation; (3) ensure the resiliency and reliabiility of energy end-use systems; and (4) understand the health and safety implications of conservation related technologies.

The focus of energy conservation is on improving the efficiency of energy use; therefore, the Conservation Research and Development Program is organized basically by energy-using sectors of the economy. These include residential and commercial buildings and community systems, transportation, and industry. Energy use in 1985 was distributed about evenly among these three sectors. In addition to these categories, there are many technologically related aspects of energy use which are common to all sectors of the economy. Combustion is one example, friction and wear is another, and the use of advanced materials in energy related equipment and high-temperature environments is a third. Hence, a fourth element of the Conservation R&D program addresses the cross-cutting aspects of energy use. This fourth multi-sector element of the program also serves as the clearinghouse for innovative concepts and inventions originating in the private sector.

In FY 1987, the Conservation Research and Development Program will carry out activities in the following budget categories:

- Buildings and Community Systems
- Industrial Programs
- Transportation
- Multi-Sector

Reductions in the Energy Conservation R&D programs are proposed in the 1987 budget consistent with budgetary constraints and the stability of our near and mid term energy supply and demand forecasts. Although provisions have been made to satisfy the requirements of the statutory programs, it is planned that legislation will be introduced to eliminate regulatory requirements that conflict with a free-market approach to providing conservation signals to energy users.

One of the primary goals of all the applied research areas in Conservation is to effectively transfer technology from Federal and university laboratories to private industry. The earlier industry is involved, and the more directly that the research agenda is guided by the companies' own economic self-interest, the more effective the transfer is likely to be. A funding approach will be explored in 1987 as an effort to increase the private leverage of Federal funds, provide industry involvement in the choice of technology development directions, and help limited Federal funds to support emerging industry more broadly. This approach is to solicit industry interest in joining together to form cooperative R&D ventures within broad sectors of the economy. This ultimately could transform most or all of the industry-performed work in Conservation, and can facilitate transfer of advanced technology to the private sector. Most areas of industry-performed Conservation R&D work offer excellent opportunities for this approach.

Cooperative ventures are potentially suited to this technology-transfer/proof-of-concept stage of activity. By law, and because of the competitive interests of the companies involved, their activity is restricted to pre-competitive (i.e., not product-specific) research and development. The cooperative ventures would be designed to meet this criterion. This matches Administration policy of supporting longer-term generic research that benefits the public, but not using tax dollars to subsidize a particular company's development of proprietary products. Support of industry-cooperative R&D allows limited Federal funds to strengthen a whole industry and not just one or a few selected players. This can clearly benefit emerging industries as well as more mature ones.

The voluntary organization of such cooperative ventures by industry would serve as a strong indicator for the proper direction of government-sponsored R&D. The pooled funding will also provide a greater degree of private cost-sharing for applied R&D, allowing Federal dollars to go farther.

If the cooperative venture is defined broadly, with a substantial membership base and level of funding, it can perform or sponsor technology development projects in a number of related areas. This serves to further reduce the risk to the participants, ensuring better chances for shared successes that will repay each party's investment.

The Department will not place tight constraints on the types of cooperative opportunities to be considered, but key characteristics of the concept include:

- Significant leveraging of Federal funding;
- The support that the Department would provide should not displace support that would otherwise come from the private sector;
- The Federal government will share in royalties or other repayment profits from the venture, proportionate to its constribution to the venture;
- Participation of two or more companies;
- Preferably ventures should include companies that have previously proven themselves successful in obtaining and managing co-funding from private sources.

As industry develops responses to this opportunity, the Department will consider reprogramming of monies to allow participation in promising cooperative ventures.

FY 1987 Congressional Budget
DECISION UNIT OVERVIEW
Buildings and Community Systems

Energy conservation in the buildings sector continues to make a significant contribution to the nation's improved energy situation. Energy consumption in buildings has been reduced 20 percent per unit of floor space since 1972 and we expect this trend to continue. Since the buildings sector uses approximately one-third of the energy consumed by our economy, such conservation may be viewed as a significant energy resource. Consequently, improved building energy efficiency is an important element of a balanced and diverse energy resource system.

The mission of the Buildings and Community Systems program is to encourage full development of the potential for economical energy conservation in residential and commercial buildings. Accordingly, program activities focus on research to advance the technologies needed for private sector development of energy efficient buildings, building equipment, and building energy supply systems. Other activities include transfer of the results of this research to industry and consumers, implementation of Congressionally mandated building energy conservation programs, and coordination of the Federal government's "in-house" energy conservation activities.

In FY 1987 the Buildings and Community Systems program will carry out activities in the following subprograms.

- o Building Systems
- o Technology and Consumer Products
- o Analysis and Technology Transfer
- o Appliance Standards
- o Federal Energy Management Program

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
BUILDINGS AND COMMUNITY SYSTEMS
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Approp.	FY 1986 Approp.	FY 1987 Base	FY 1987 Request	Request vs Base
Buildings and Community Systems					
Building Systems	$14,560	$12,099	$12,099	$ 3,500	$ -8,599
Community Systems	5,390	3,727	3,727	0	-3,727
Urban Waste	980	0	0	0	0
Technology and Consumer Products	9,997	10,053	10,053	5,000	-5,053
Analysis and Technology Transfer	980	2,559	2,559	1,000	-1,559
Appliance Standards	2,450	1,863	1,863	1,200	-663
Federal Energy Management Program	1,274	1,187	1,187	1,050	-137
Residential Conservation Service	1,274	372	372	0	-372
Program Direction	2,895	3,557	3,557	2,400	-1,157
Subtotal					
Operating Expenses	39,800	35,417	35,417	14,150	-21,267
Capital Equipment	1,225	1,863	1,863	0	- 1,863
Total					
Buildings and Community Systems	$41,025	$37,280	$37,280	$14,150	$-23,130
Staffing Total FTE's	57	71	71	45	-26

Authorization: P.L. 93-577, as amended, Energy Research and Development Act
P.L. 94-163, Part E (Sec. 381), Energy Policy and Conservation Act
P.L. 94-385, Energy Conservation and Production Act
P.L. 94-438, Energy Reorganization Act of 1974
P.L. 95-618, (Title I), Energy Tax Act
P.L. 95-619, (Sec. 224, Parts 1, 2, 4; Sec. 210-223; and Sec. 501, 541-551), National Energy Conservation Policy Act
P.L. 95-620, Power Plant and Industrial Fuel Use Act of 1978
P.L. 96-294, Energy Security Act
RCS: National Energy Conservation Policy Act, as amended by Energy Security Act;
CACS: Energy Security Act

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	Gramm-Rudman-Hollings Reduction	Adj. Approp. Total
Buildings & Community Systems						
Building Systems	$13,000	$ -78	$ -280	$ ---	$ -543	$12,099
Community Systems	4,000	-20	-86	---	-167	3,727
Residential Conservation Service	400	-2	-9	---	-17	372
Technology & Consumer Products	10,800	-63	-232	---	-452	10,053
Appliance Standards	2,000	-10	-43	---	-84	1,863
Analysis & Technology Transfer	2,750	-17	-59	---	-115	2,559
Federal Energy Management Program	1,275	-8	-27	---	-53	1,187
Capital Equipment	2,000	-10	-43	---	-84	1,863
Program Direction	3,200	-19	-82	618	-160	3,557
Subtotal, Buildings and Community Systems	$39,425	$ -227	$ -861	$ 618	$-1,675	$37,280
General Reduction:						
Operating Expenses.........	$ -217	$ 217	$ ---	$ ---	$ ---	$ ---
Capital Equipment	-10	10	---	---	---	---
Total, General Reduction	$ -227	$ +227	$ ---	$ ---	$ ---	$ ---
Management Initiatives:						
Operating Expenses.........	$ -818	$ ---	$ 818	$ ---	$ ---	$ ---
Capital Equipment	-43	---	43	---	---	---
Total, Management Initiatives	$ -861	$ ---	$ 861	$ ---	$ ---	$ ---
Pay Restoration	618	---	---	-618	---	---
Total, Buildings and Community Systems	$38,955	$ ---	$ ---	$ ---	$-1,675	$37,280
Operating Expenses ...	$37,008	$ ---	$ ---	$ ---	$-1,591	$35,417
Capital Equipment	1,947	---	---	---	-84	1,863

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
ENERGY CONSERVATION
BUILDINGS AND COMMUNITY SYSTEMS
(In thousands of dollars)

FY 1986 Conference mark less G-R-H adjustment	$37,280
Built in increases and decreases:	
None	0
FY 1986 Adjusted and FY 1987 base	$37,280
Program increases and decreases:	
Buildings Systems	
o Building materials research	-1,024
o Building subsystems research	
-Walls research	- 476
-Fenestration research	-1,489
-Lighting requirements research	- 186
-Indoor air quality, infiltration and ventilation	+ 132
o Building systems integration research	
-Commercial building systems interactions	- 930
-Residential building systems interactions	- 838
-Performance calculations	- 744
-Building energy control systems	- 93
o Building energy retrofit research	
-Single family retrofit research	- 736
-Multifamily retrofit research	- 702
-Commercial building retrofit research	- 796
o Energy conservation standards and guidelines	- 717
Subtotal	$-8,599
Community Systems	
o District heating and cooling	
-Systems and components research	-1,020
-Feasibility studies	- 657
o Community energy systems integration	
-Urban Consortium	-1,864
-Site design	- 186
Subtotal	$-3,727

Technology and Consumer Products

o Thermally activated heat pumps	- 364
o Advanced refrigeration systems	-2,131
o Combustion systems research	- 655
o Lighting equipment research	- 962
o Equipment integration research	- 941
Subtotal	$-5,053

Analysis and Technology Transfer

o Technical assessment and analysis	- 50
o Utility applications research	- 951
o Rural Housing Amendments Act study	- 308
o Research utilization	- 450
o Technology transfer	+ 200
Subtotal	$-1,559

Appliance Standards

o Test procedures development and consumer education	- 790
o Appliance standards development	+ 127
Subtotal	$- 663

Federal Energy Management Program

o Federal planning, reporting and evaluation	+ 100
o Technical guidance and assistance to Federal agencies	- 237
Subtotal	$- 137

Residential Conservation Service

o Commercial and Apartment Conservation Service	- 372
Subtotal	$- 372

Program Direction

o Price out of staffing	-1,157
Subtotal	$-1,157

Capital Equipment

o Laboratory and field test equipment	-1,863
Subtotal	$-1,863
FY 1987 budget request	$14,150

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
NARRATIVE JUSTIFICATION
ENERGY CONSERVATION
BUILDINGS AND COMMUNITY SYSTEMS

The goal of the Buildings and Community Systems (BCS) program is to advance technologies that will increase the energy efficiency of the built environment. This goal is being achieved through a comprehensive research program, transfer of the results of this research to the private sector, and implementation of DOE's statutory responsibilities in the buildings area.

Accomplishments for FY 1985 and anticipated accomplishments for FY 1986 include:

- Developed and promulgated interim standards for new commercial buildings and new Federal residential buildings (including manufactured housing).
- Initiated a collaborative effort to predict, measure and control radon concentrations in homes in coordination with an epidemiological study by DOE's Office of Health and Environmental Research.
- Completed a systems integration study of multifamily midrise and highrise buildings and published a handbook of research findings as a guide to energy-conserving designs.
- Completed guidelines for energy efficient site-built single family residences and produced manuals and slide rules for designers and builders.
- Validated a laboratory method for measuring the static thermal performance of large, complex wall sections. Developed an improved method for testing and predicting the performance of complex fenestration designs.
- Completed a detailed assessment of technical issues concerning ureaformaldehyde foam insulation.
- Developed scope of work, organized the research, and identified methods to renovate old steam district heating systems using the Scranton, Pennsylvania, system as a laboratory. Completed drilling, water characteristics analysis, and tests of heat exchangers for a mine-water heat recovery project.
- For district heating and cooling systems initiated research aimed at enhancing the energy delivery capacity of fluids using drag reduction additives (slippery water) and phase change material (liquid ice) for increased cooling capacity.
- In cooperation with the communities involved, completed assessment of the applicability of district heating and cooling in 15 additional communities.

- Supported the Urban Consortium Energy Task Force in conducting 20 local government conservation energy projects and 4 regional workshops to share the results of successful projects with other local communities.

- Through seven workshops conducted by the U.S. Conference of Mayors, disseminated information and technology about district heating and cooling to city officials, planners, developers and engineers to assist them in applying district heating and cooling systems to their communities.

- Completed design and laboratory validation of two important heat pump developments: a prototype optimized ground-coupled heat pump mechanical package, and a breadboard advanced cycle absorption heat pump for residential use which verified the performance potential of the selected cycle.

- Completed evaluation of alternate cycle concepts using non-azeotropic refrigerant mixtures and initiated laboratory experiments to develop refrigerant separation techniques for composition control.

- Completed characterization of corrosion and physical-chemical behavior of selected stainless steels as part of the effort to solve the corrosion problem in condensing heat exchangers.

- Improved the efficiency of fluorescent lamps by nearly 35 percent by combining the effect of both isotope enrichment and magnetic enhancement.

- Issued final rules amending test procedures for water heaters to include heat pump water heaters, and amending the procedures for central air conditioners to reduce testing burden and increase accuracy.

- Established a Building Energy Accounting System (BEAS) to provide readily available, computerized historic data and projections on the characteristics, energy consumption, and energy conservation of buildings, and to publish an annual Building Energy Data Book.

- Developed and implemented a program that in cooperation with the utility industry will make available needed analytical tools and data that can be used to determine the impact of energy conservation on utility long-term demand-side planning.

- Conducted research that led to the incorporation of more effective equipment retrofit measures in existing low-income weatherization programs; determined that such measures can substantially increase the energy savings realized.

- Initiated cooperative research with the Department of Housing and Urban Development directed at conserving energy in existing, Federally assisted housing.

- Developed standard protocols for coordinating retrofit research in residential buildings and participated in cost-shared research directed at measuring the effectiveness of single-family retrofit activities.
- Identified technical and behavioral problems that may be reducing the effectiveness of building retrofit measures.

Accomplishments in the area of Residential Conservation Service:

Over a million Residential Commercial Service audits were provided in FY 1985, bringing the total to more than 4 million since program inception. Commercial and Apartment Conservation Service program implementation has continued. About half the States now have approved plans for Commercial and Apartment Conservation Service program implementation.

Studies have been initiated to identify promising program alternatives and means of assisting States, utilities, or community level organizations in implementing energy conservation programs. These studies also support the evolution of the Federal role from a regulatory basis to encouraging voluntary participation. The studies suggest that a flexible and multifaceted approach, facilitated by Federally-sponsored technical and information resources, is needed to assist States, utilities, and others in the operation of conservation and demand-side management programs to increase energy efficiency in residences and small-to medium-sized commercial buildings. Examples include:

- Qualitative Analysis of alternative audits, financing, direct installation and marketing programs offered by utilities in California, Florida, Michigan, Nebraska, Oklahoma and Texas.
- Evaluation of Florida Power and Light (FPL) "HELP" program, which includes a simplified audit and subsidized installation of low-cost measures, to assess auditor marketing skills, extent of customer action on HELP recommendations, and relationship to other FPL residential programs.
- Evaluation of General Public Utilities (GPU) "RECAP" program, which offers selected Pennsylvania and New Jersey residents retrofits financed through shared savings. Analysis focuses on contracting arrangements, marketing, energy savings, behaviorial and comfort changes, and shifts in electrical load shape.
- Analysis of key operational and management factors in the "Weatherize Portland" (ME) program to identify those factors contributing to the success of this comprehensive multi-partner program which incorporates the RCS audit within a full-service program.

- An update of the evaluation of the RCS program to provide current information on overall program results, the effects of rebates, low-interest loans, direct installation, and other corollary utility programs on RCS participation, and a survey of States' and utilities' plans to continue with RCS or implement follow-on programs.

As electric utilities place more emphasis on demand-side activities, and other State and local program implementers seek solutions to energy problems, there is an interest in and need for a wide range of information and technology transfer. DOE has assisted in meeting this need through a variety of activities. For example:

- DOE, the Electric Power Research Institute and the Alliance to Save Energy co-sponsored the Second National Energy Efficiency Conference. This was held in conjunction with an energy exposition held in San Francisco, California and sponsored by the Pacific Gas and Electric Company in May 1985. Over 700 utility professionals, government officials and corporate energy managers attended. Topical sessions covered new strategies for program design, evaluation, technical developments, policy issues and marketing. Plenary sessions also provided a variety of national perspectives by representatives from energy industries, universities, Congress and the Executive Branch.

- In September 1985, DOE sponsored the "Conference on Commercial and Apartment Conservation Programs" in Minneapolis, Minnesota. Representatives from State energy offices, utilities, local housing authorities and energy service companies attended. The majority of the sessions addressed some aspect of marketing: identification, segmentation, approaches, or other issues and techniques. Other sessions presented commercial/multifamily research results and actual program experience.

Departmental Request

Funding requested for the Buildings and Community Systems program in FY 1987 is $14,150,000. The reduction of $23,130,000 compared to the FY 1986 appropriation results from the discontinuation of funding for capital equipment and one subprogram, the transfer of a second subprogram, and the discontinuation of a number of activities in the remaining subprograms. The Community Systems subprogram is being discontinued after funding district heating and cooling feasibility studies in more than 50 communities, showing the potential of this technology, and encouraging other communities to undertake such studies on their own. The Residential Conservation Service subprogram has been transferred to the Office of State and Local programs and is discussed in that section of the budget request.

Funding is requested in FY 1987 for Program Direction and for activities in the following subprograms:

- o Building Systems
- o Technology and Consumer Products
- o Appliance Standards
- o Analysis and Technology Transfer
- o Federal Energy Management Program

Building Systems..$3,500,000

The objective of the Building Systems subprogram is to encourage optimal use of energy in U.S. buildings. Long-term generic research is conducted to advance the knowledge of energy transfer phenomena in buildings and the results of that research are provided to practitioners in the building industry. The FY 1987 budget request for this subprogram is $3,500,000. This represents a reduction of $8,599,000 compared to the FY 1986 appropriation. This funding level will allow research and development in the Building Subsystems and Standards and Guidelines activities to be continued.

The Building Subsystems research activity addresses the energy-related characteristics of the several elements and components that, when assembled, constitute a building system. A significant portion of the research is directed toward determining analytical relationships among physical properties of individual subsystems and the flow of energy and mass (e.g., moisture and air) through the subsystems. These analytical relationships then form the bases for models used to predict the energy performance characteristics of subsystems. Laboratory and field testing programs are conducted to validate these models and to establish data bases to be used by practitioners in the building community. Research in this activity is also directed toward providing a supporting technical basis for the development of guidelines and voluntary standards for use in designing more energy efficient building elements. In FY 1987 efforts in this key activity will include research in walls; roofs; and indoor air quality, infiltration, and ventilation.

Walls research is conducted to determine those characteristics of walls that influence the conservation effectiveness of buildings. The research is divided into thermal testing of walls; evaluation of thermal wall anomalies; an evaluation of mass influence on energy utilization; and the study of foundation design and earth contact. Research in FY 1986 includes the development of dynamic thermal testing protocols; analysis of thermal mass modeling and prediction techniques; measurement, modeling, and evaluation of thermal bridges, breaks, convective loops and other thermal anomalies; and the planning for future foundation and earth contact research. Research in FY 1987 will emphasize studies of innovative wood, lightweight concrete and other foundation insulating techniques. Moisture effects on overall energy performance of walls and foundations will be evaluated and development of analytical models for predicting foundation thermal performance will be initiated. Dynamic testing of innovative wall constructions will be initiated, and the effect of thermal mass in multifamily residential structures will be evaluated.

In FY 1986, roof research focuses on improving energy efficiency and durability characteristics of roof systems. Research areas include developing an integrated mathematical model to predict thermal performance of composite roofs, thermal performance testing of high and low efficiency roofs under field conditions, and developing diagnostic probes for quantitative moisture measurements in roof systems. In FY 1986, a roof model is being developed to simulate thermal and moisture transport behavior of roofs. In FY 1987, this model will be expanded to include effects of mechanical and structural stress. In FY 1986, development of non-destructive and intrusive moisture measuring instruments using electrical capacitance and resistance is continuing. These instruments will be completed and calibrated in FY 1987. In FY 1986, studies of the effects of solar absorptance and ultraviolet radiation on thermal performance will be completed. In FY 1987, effects of thermal bridging and wet insulation on thermal performance will be evaluated. An industry advisory panel is assisting in developing roof research plans.

Indoor air quality, infiltration, and ventilation research in FY 1986 includes collection of infiltration and ventilation measurements in large buildings. Collaborative interagency efforts to study the generation and distribution of biological aerosols is continuing. Development and evaluation of infiltration, ventilation, and air leakage measurement systems for multifamily buildings is being completed. Development of a simplified multizonal infiltration and ventilation model is continuing and a study of occupant behavior effects on infiltration and ventilation performance is being initiated. Assessment of ambient indoor radon levels, characterization of radon building entry mechanisms, and field studies on radon control and mitigation are continuing. Research to develop, test, and evaluate energy efficient and cost-effective strategies to maintain indoor air quality is continuing, and interagency efforts to model indoor air quality are being initiated. Collaborative efforts to develop voluntary consensus standards for indoor air quality, and interagency coordination of indoor air quality research are continuing. In FY 1987, research will continue and the newly initiated FY 1986 efforts will be expanded in all the areas described above except the study of occupant behavior effects on infiltration and ventilation performance. That study will be discontinued.

The Standards and Guidelines activity is a Congressionally mandated, multiyear effort to develop energy conservation standards and guidelines for new commercial and residential buildings (including manufactured housing). The Energy Conservation Standards for New Buildings Act, as amended, requires that DOE develop and promulgate interim standards and then final standards for each classification. The standards are mandatory for Federal agencies only. They are to serve as voluntary guidelines for the non-Federal sector. The Act also requires DOE to conduct demonstration projects for each standards activity and report the results to the Congress. FY 1987 funding will be used to complete development and prepare the Notice of Proposed Rulemaking for the interim voluntary residential and manufactured housing standards.

Technology and Consumer Products..$5,000,000

The purpose of the Technology and Consumer Products subprogram is to provide the technological basis for improved, energy efficient building energy conversion processes and equipment. Research is conducted to investigate, develop, and test generic technical approaches and engineering concepts with potential for substantially increasing the efficiency with which raw energy in the form of oil, gas, solid fuels and electricity is converted into useful energy in the form of heat, refrigeration, and lighting.

The FY 1987 budget request for Technology and Consumer Products is $5,000,000. This represents a reduction of $5,053,000 compared to the FY 1986 appropriation. This reduction is achieved by discontinuing research in the technologies supporting combustion systems and advanced refrigeration systems, and by curtailing research in lighting equipment technologies. The greatest promise for significant energy savings in the Technology and Consumer Products subprogram is in the areas of thermally activated heat pumps and advanced lighting equipment. Therefore, funding is requested for continued research in these areas.

Thermally Activated Heat Pumps: This activity consists of research on engine driven and absorption heat pump systems. During FY 1986, proof-of-concept testing on novel advanced cycle absorption heat pumps using conventional fluids and ternary mixtures, research on free piston Stirling (FPS) and internal combustion (IC) engine driven heat pumps component fabrication, and supporting research on FPS engine/compressor dynamic interaction and model development continued. In FY 1987, proof-of-concept testing of novel advanced cycle absorption heat pumps, research on novel sealing concepts for engine driven systems, field evaluation of a commercial IC engine heat pump, and evaluation of low loss hydraulic compressor Stirling engine driven heat pumps will continue. Successful research in this area has the potential of saving about 4.0 quads of energy annually.

Lighting Equipment Research: This activity consists of research on light sources and the optimized integration of lighting system components into the total building. During FY 1986, research was focused on characterizing lamp discharge efficiency improvements through experimental, diagnostic investigation of low and high pressure discharge phenomena. In FY 1987, research will continue to investigate this improvement in efficiency of magnetically loaded lamps and electrodeless, surface wave (gigahertz) lamp discharges. Initial work will concentrate on lamp driving concepts and prototype development of a scaled down electrodeless high intensity discharge lamp with novel gas radiator fills. Non-intrusive diagnostic techniques for characterizing lamp discharges will be developed and applied, and lighting system components for advanced designs will be characterized for designed building spaces. No funding is requested for studies of efficiency improvement through mercury isotope enrichment or for development of mercury isotope separation processes since the comparative evaluation of separation techniques will be completed with FY 1986 funding. Successful lighting equipment research has the potential of saving 1.5 quads of energy.

Analysis and Technology Transfer......................................$1,000,000

The purpose of the Analysis and Technology Transfer subprogram is to ensure that research results and information on conservation in buildings are transferred to the private sector, and to conduct the necessary analysis to support program planning. The FY 1987 budget request for this subprogram is $1,000,000, a reduction of $1,559,000 compared to the FY 1986 appropriation. This funding will support centralized technology transfer activities and continuation, at a reduced level, of the analysis activities. It includes continued support for U.S. participation in International Energy Agency (IEA) agreements, technology assessments, and policy and program analysis.

The requested funding is necessary to ensure that U.S. citizens benefit fully from BCS programs. The analysis activity ensures that the most beneficial building energy conservation research projects are conducted and that they are conducted to most effectively complement private sector activities. The technology transfer activity not only ensures that technical knowledge is quickly, effectively, and efficiently disseminated, but that knowledge about what building conservation programs work for utilities, local governments and the private sector is made easily accessible. In FY 1987, technology transfer will provide a capability to monitor research progress to ensure early, effective transfer of the results, publish state of the art and cross-cutting (i.e., integrating results across programs) reports, and coordinate with private sector associations and other organizations.

No FY 1987 funding is requested for utility applications research which is being discontinued, or for the Rural Housing Amendments Act Study since it is being completed with FY 1986 funds.

Appliance Standards...$1,200,000

The FY 1987 budget request for Appliance Standards is $1,200,000. This represents a reduction of $663,000 compared to the FY 1986 appropriation. This reduction is achieved by discontinuing research in appliance test procedures. Appliance standards development is maintained at approximately the same level as in FY 1986.

The purpose of the Appliance Standards activity is to conduct the analysis and regulatory activities necessary to comply with the Energy Policy and Conservation Act (EPCA), as amended. In 1987, the Department will conduct research and analysis on the impacts of appliance standards including a reevaluation of those previously issued. This reevaluation is required by a recent U.S. Court of Appeals decision and by section 325(h) of EPCA which specifies that it be completed by FY 1988. The analysis will consider the energy performance and cost of advanced prototype models of the covered appliances as well as foreign models; the economic justifiability of standards. including their impact on manufacturers; and the energy savings that result from any standards regulation.

Federal Energy Management Program..................................$1,050,00

The Federal Energy Management Program (FEMP) is a Federally directed effort to reduce energy use by Federal agencies, improve utilization efficiency, conserve scarce fuel, and transfer energy management experience among Federal agencies, IEA member nations, State and local governments, and the private sector. The FY 1987 budget request for FEMP is $1,050,000. This is a reduction of $137,000 compared to the FY 1986 appropriation. It will be achieved by reducing the technical guidance and assistance provided to other Federal agencies. Evaluation of shared savings contracting will be increased.

The requested FY 1987 funding is necessary to continue the implementation of Federal laws and Executive Orders pertaining to energy conservation in the Federal government; prepare annual reports to the President and Congress; monitor Federal agency conservation activities and performance; assist agencies in developing and implementing energy conservation programs; and provide them with technical guidance (i.e., "How to" manuals, workshops on "Life Cycle Cost" analyses and "Energy in Design," courses on shared-savings contracting, and employee awareness programs). Training materials and workshops for Federal architects and engineers to acquaint them with the recently issued mandatory standards for existing buildings will be continued and will be opened to private architectural and engineering firms. Support will be provided to Federal agencies to demonstrate the new interim standards as required by the Energy Conservation Standards for New Buildings Act. A mechanism for exchanging experiences and information among IEA member nations on effective retrofit measures in public buildings will be developed.

	FY 1985	FY 1986	FY 1987 Congessional Request
RESIDENTIAL CONSERVATION SERVICE	$1,274,000	$ 372,000	-0-

The FY 1987 budget request provides no funding for Residential and Commercial Conservation (RCC) which includes the Residential Conservation Service (RCS) and the Commercial and Apartment Conservation Service (CACS). This funding level represents a $372,000 decrease from FY 1986.

In FY 1986, implementation of CACS will continue, and the CACS Federal standby programwill be initiated. The funds will be used to support technical review of CACS state plan amendments and CACS Federal standby procedures proposed by utilities in Federal standby states, to provide limited technical assistance to those states and utilities and to monitor and evaluate the CACS and CACS standby programs.

There will be little DOE activity in FY 1986 related to RCS. The requirement that utilities disseminate RCS program announcements terminated January 1, 1985, and it is assumed that many utilities phased down their RCS programs over the course of 1985. An updated evaluation report will be issued and results shared with States, utilities, and other interested parties. Monitoring of utility supply installations and financing activities will continue.

Consistent with the shift away from a Federal regulatory role, activities were initiated in FY 1985 to encourage voluntary utility energy efficiency programs which are more cost effective than RCS and better suited to utility needs. These activities will continue in FY 1986 on a limited basis.

In FY 1987 Federal support for RCS and CACS will be terminated. Limited staff assistance will be provided to utilities and related groups to encourage voluntary energy efficiency programs using non-Federal funds.

Program Direction..$2,400,000

The FY 1987 budget request for Program Direction is $2,400,000. This represents a reduction of $1,157,000 compared to the FY 1986 appropriation. The requested funding will provide salaries, benefits and travel for a staff of 45 FTE's to manage the Buildings and Community Systems program.

DEPARTMENT OF ENERGY

FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
INDUSTRIAL ENERGY CONSERVATION

(Tabular dollars in thousands. Narrative material in whole dollars.)

Departmental Request	FY 1985 Approp.	FY 1986 Approp.	FY 1987 Base	FY 1987 Request	Request vs. Base
Waste Energy Reduction					
Operating Expenses	$11,859	$11,174	$11,174	$ 6,300	-$ 4,874
Capital Equipment	-0-	-0-	-0-	-0-	-0-
Subtotal	$11,859	$11,174	$11,174	$ 6,300	-$ 4,874
Industrial Process Efficiency					
Operating Expenses	$ 9,556	$19,551	$19,551	$ 5,479	-$14,072
Capital Equipment	1,156	-0-	-0-	-0-	-0-
Subtotal	$10,712	$19,551	$19,551	$ 5,479	-$14,072
Industrial Cogeneration					
Operating Expenses	$ 4,116	$ 4,377	$ 4,377	$ 1,500	-$ 2,877
Capital Equipment	1,000	-0-	-0-	-0-	-0-
Subtotal	$ 5,116	$ 4,377	$ 4,377	$ 1,500	-$ 2,877
Implementation & Deployment					
Operating Expenses	$ 2,212	$ 2,978	$ 2,978	$ 500	-$ 2,478
Capital Equipment	-0-	-0-	-0-	-0-	-0-
Subtotal	$ 2,212	$ 2,978	$ 2,978	$ 500	-$ 2,478
Program Direction					
Operating Expenses	$ 1,807	$ 2,016	$ 2,016	$ 1,844	-$ 172
Subtotal	$ 1,807	$ 2,016	$ 2,016	$ 1,844	-$ 172
Total					
Operating Expenses	$29,550	$40,096	$40,096	$15,623	-$24,473
Capital Equipment	2,156	-0-	-0-	-0-	-0-
Total - Industrial Energy Conservation	$31,706	$40,096	$40,096	$15,623	-$24,473
Staffing Total FTE's	33	35	35	26	-9

AUTHORIZATION: P.L. 93-572, "Federal Non-Nuclear Energy Research and Development Act of 1974"
P.L. 95-619, "National Energy Conservation Policy Act"
P.L. 94-163, "Energy Policy and Conservation Act"
P.L. 93-438, "Energy Reorganization Act"
P.L. 95-91, "Department of Energy Reorganization Act"

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	Gramm-Rudman Hollings Reduction	Adj. Approp. Total
Industrial Energy Conservation						
Waste Energy Reduction	$ 12,006	$ -72	$ -258	$ ---	$ -502	$11,174
Industrial Process Effic.	21,000	-119	-452	---	-878	19,551
Industrial Cogeneration	4,700	-25	-101	---	-197	4,377
Implementation & Deployment	3,200	-19	-69	---	-134	2,978
Program Direction	1,927	-12	-47	238	-90	2,016
Subtotal, Industrial Energy Conservation	42,833	-247	$ -927	$ 238	$-1,801	$40,096
General Reduction: Operating Expenses..........	-247	+247	---	---	---	---
Management Initiatives: Operating Expenses..........	-927	---	+927	---	---	---
Pay Restoration	+238	---	---	-238	---	---
Total, Industrial Energy Conservation	$41,897	$ ---	$ ---	$ ---	$-1,801	$40,096
Operating Expenses	41,897	---	---	---	-1,801	40,096

DEPARTMENT OF ENERGY

FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
INDUSTRIAL ENERGY CONSERVATION
(In Thousands of Dollars)

President's FY 1986 Appropriation	$40,096
Waste Energy Reduction	
- Decreased Effort on Improved Combustion Efficiency	- 259
- Reduced High Temperature Recuperators R&D	- 1,730
- Reduced Industrial Heat Pumps R&D	- 1,298
- Increased Effort on CO_2 Utilization	+ 345
- Decreased Effort on Waste Utilization	- 778
- Decreased Program Support	- 1,154
Industrial Process Efficiency	
- Decreased Thin Strip Casting Research	-12,486
- Decreased Electrode Materials R&D	- 933
- Decreased Coatings Research	- 187
- Decreased Sensors & Controls R&D	- 466
Industrial Cogeneration	
- Decreased Effort for Externally Fired Brayton	- 2,175
- Decreased Effort on Direct Conversion R&D	- 362
- Decreased Effort on Bottoming Cycles Conversion	- 182
- Decreased Activity on Coal-Slurry Diesel	- 158
Implementation and Deployment	
- Decreased Funds for Technology Transfer	- 814
- Decreased Funds for Energy Audit & Diagnostic Centers	- 1,386
- Decreased Funds for Industrial Reporting	- 278
Program Direction	- 172
FY 1987 Departmental Request	$15,623

Program Objectives and Strategy:

The goal of the industrial energy conservation program seeks to increase energy use efficiency and improve industry's ability to utilize the most cost-effective fuels, via a program of carefully targeted technology research and development activities. The program is focused on high risk development which is in the national interest and for which private industry has insufficient incentive to pursue independently. Most of the activities are conducted by private institutions operating under cost-shared contracts or cooperative agreements with the Department. The industrial energy conservation program is aimed at providing: cost-effective technology options that are available to industry for reducing energy losses embodied in waste streams, waste materials and inefficient processes; technologies which can provide greater fuel flexibility; and the transfer of the technical information to industry for the rapid deployment of the new technologies.

Examples of research and development activities being pursued include:

- Large scale industrial heat pumps that can economically upgrade waste heat to useful process steam.
- High temperature recuperators that can operate in dirty and corrosive waste streams at temperatures up to 2600°F.
- Development of coal-fired equipment that can be retrofitted into existing gas and oil-fired industrial furnaces and boilers.
- Research and development of cost-effective technologies which will make the conversion and/or retrieval of materials from waste streams practical and attractive to industry.
- Advanced sensors and control systems to enable more precise control of energy-intensive processes.
- Electrode materials development to improve operating efficiency of electrolytic cells.
- Direct casting of thin steel strip to eliminate energy-intensive reheating and rolling operations.
- Research and development of separation systems, including membranes, to economically and efficiently replace energy inefficient separation processes.
- Effective means of communicating with the industry sector for the rapid transfer of technology research and development.

Accomplishments for FY 1985 and Anticipated Accomplishments for FY 1986:

- Testing of an Air-Fuel ratio control device developed by DOE on a Potomac Electric utility boiler was completed. Funding for the test was provided by EPRI.
- Three high temperature prototype heat exchangers were installed at industrial sites and proof-of-concept testing was started.
- A study on the circulating fluid bed concept for the externally- fired Brayton cogeneration system was completed.
- A series of test runs were completed on a slow speed diesel test engine using three different coal/water slurries. Some runs were continued for a period of 7-8 hours duration.
- Field testing of two sensors started at paper mills for improved on-line control of processes.
- Completed testing of a new gasification process for paper mill black liquor which makes it safer to recover pulping chemicals and improves the overall recovery of energy from the black liquor processing.
- A project to more efficiently remove water during the paper making process was completed and a technology transfer conference on the results was held with industry representatives.
- Two contracts were commenced to develop the technology for thin strip casting of steel.
- Field testing will be completed on two high temperature prototype heat exchangers.
- A Brayton solvent recovery system prototype will complete its testing at an industrial site.

- A plating chemicals recovery system will complete its long term testing at an industrial site.
- Large scale testing for the recovery of CO_2 from large boiler exhaust stacks will be started.
- Two large scale prototype slagging combustors will complete testing to show the feasibility of retrofitting industrial oil and gas fired boilers for coal fuel use.
- Topping combustor tests will be completed to show feasibility of use for the externally coal-fired Brayton cogeneration system.
- Proof-of-concept testing of a BiPhase turbine unit will be started for separation of oil and gas at an oil processing station.
- Testing of two sensors at paper mills will be completed.
- Laboratory testing of a 120 watt prototype sodium heat engine will be completed.
- The seven Energy Integrated Farm projects will be completed and operational information will be available in final reports.
- Complete installation of the horizontal caster for thin strip casting at the U.S. Steel research facility.

Budget Request

The Office of Industrial Programs' FY 1987 Congressional Budget Request is $15,623,000 which is $21,173,000 less than the FY 1986 Appropriation.

Five subprograms of the industrial energy conservation program encompassing specific objectives and strategies to meet the overall industrial program objectives are:

- Waste Energy Reduction
- Industrial Process Efficiency
- Industrial Cogeneration
- Implementation and Deployment
- Program Direction

In the following sections each of these subprograms is discussed in detail including the activities carried out with the requested budget level. Although this is the current plan for the activities within the subprograms there could be variations from project-to-project based on the findings of subsequent research stages.

	FY 1985	FY 1986	FY 1987 Request
Waste Energy Reduction:	$11,859,000	$11,174,000	$ 6,300,000

The FY 1987 Congressional Budget Request is $6,300,000. This is $4,874,000 less than the FY 1986 Appropriation. The goal of Waste Energy Reduction is to conduct research and to develop energy efficient technologies to recover energy contained in industrial waste streams and waste materials, and to more efficiently utilize the energy content of fuels. The research is addressed within three district areas: waste heat recovery, combustion efficiency, and industrial waste utilization. National laboratory management support and analysis for all of the industrial energy conservation program is included in this subprogram and support services.

The Waste Energy Reduction activities for FY 1987 have generally been reduced from the prior fiscal year request, in order to focus the work on longer-term, higher-risk areas of research. The economic self-interest of firms provides a strong incentive for the adoption of waste energy reduction concepts as soon as they are shown to be viable. The joint coal burner development with Fossil Energy will be concluded in FY 1986 and no additional effort will be undertaken in FY 1987. Efforts in the recuperator and heat pump programs have been realigned in FY 1987 to minimize any hardware development and to concentrate on materials development and laboratory studies of systems and application potential. Waste utilization project activity has been reduced to concentrate in fewer but high potential energy reclamation areas of liquid and solid wastes. The project for the generation and recovery of CO_2 from large coal-fired boilers has been increased in funding to complete a larger scale test of the technology to observe effects of larger scale operation on boiler performance. Program support functions at INEL, PNL, ANL &

ORNL for project monitoring and proposal evaluation, as well as analytical support by selected contractors, has been reduced.

Combustion Efficiency: Combustion efficiencies range up to about 80 percent depending on process and system design and there is a need for technology which enhances the fuel flexibility of industrial systems and for more efficient combustion and heat transfer within the furnaces, boilers, and process heaters. The improved combustion efficiency program concentrates on these technology development areas.

The development of technology for using oxygen enriched combustion air will increase the overall efficiency of the combustion process through increased flame temperature, decreased excess air, decreased nitrogen pass-through, and higher combustion air preheat.

Oxygen enrichment activities in FY 1986 will be continued with the laboratory study and testing of combustors using enriched combustion air. In addition FY 1986 funds will be used to continue research on combustion controls for high temperature oxygen enriched combustion air to meet the faster response required by the high temperatures. In FY 1987 these activities will be continued, including improvements in heat transfer and fouling/corrosion control techniques.

The advanced slagging and non-slagging coal combustor development activity funded jointly with Fossil Energy will be concluded in FY 1986.

Waste Heat Recovery: This activity area is intended to establish a strong technology base to address current deficiencies which prohibit timely development of ceramic heat recuperators and heat pump technology for a wide range of industrial waste heat sources. Current heat recuperator technology cannot be effectively applied without severe degradation in performance or high cost penalties to an estimated 2 quads of thermal energy wasted with corrosive and potentially fouling high temperature exhaust systems. High temperature waste stream data is needed to solve problems and limitations of present heat exchanger technology. Similarly, development of new heat pump technology is needed to allow upgrading of an estimated 3.5 quads of process liquid and gas waste heat to a more useful process temperature level.

High temperature ceramic materials development will be continued in FY 1986 and FY 1987. The low cost silicon powder development will be completed in FY 1986 and the results will be disseminated to industry. In FY 1987, funds will be used to develop a gel casting technique, research on composite ceramics, and use of woven shapes coated with chemical vapor deposited materials. In FY 1986 work will continue on non-destructive test methods and service life prediction methods for ceramic heat exchanger components which operate in severe environments. This work will be completed in FY 1987 and sample flawed materials will be tested in the laboratory under various thermal environments to develop lifetime prediction techniques.

In FY 1986 concepts for various heat pump systems (chemical, magnetic, Rankine) will be evaluated and design studies initiated. Alternative working fluids for the systems will be included in the evaluation. Predictions of expected performance will be made. In addition the utilization of a new analysis technique, "pinch network analysis", will be explored for determining where heat pumps can be integrated into manufacturing processes. This design and analysis work will be continued with FY 1987 funds based on the network analysis work. A laboratory breadboard model of a heat of reaction concept heat pump will be built and tested to verify analytical predictions.

Industrial Waste Utilization: A variety of solid and fluid waste materials presenting serious environmental problems for industry could be economically recycled or converted into useful fuels or energy-intensive products, if suitable specialized technology existed. Innovative mechanical, biochemical and thermo-chemical processes for converting solid and liquid wastes into fuels and feedstocks, and for recovering and recycling organics, inorganics, fibers, used oils, and metals, are needed to foster the development of substantial new private industrial activity in this area.

In FY 1986 and FY 1987 biological waste conversion will be continued on various industrial wastewater streams and in FY 1987 paper mill liquid wastes will be treated using enhanced biological strains to improve the production of methane. The use of membranes for separation of high oil or organic content waste streams will be explored and the economics of separation will be evaluated. Various activities concerned with solid wastes will be continued in FY 1986 and FY 1987. Specifically, utilization of asphalt roofing wastes, discarded tires, auto shredder wastes, and textile wastes for use as fuels will be continued. Textile waste fibers are also being considered as a strengthener and filler for some injection molded plastic parts.

Laboratory investigation of waste CO_2 recovery from stack gases will continue in FY 1986 with a scale up of combustion testing in a 6 million Btu/Hr furnace. This work will be continued in FY 1987 to determine scale-up effects including cold wall radiant effects and deposits on boiler tubes. Industry appears very interested in this concept and if the 6 million Btu/Hr tests are successful, work will proceed on transferring the technology to them for a pilot scale test.

The laboratory test work on producing diesel fuel from cellulosic materials was completed in FY 1985 and a technical paper on the results was presented at the Biomass Energy Regional Association Conference. In FY 1986 work was continued on the drying of in-forest wood residues. A site test will be conducted to complete the activity.

Laboratory and Analytical Support: National laboratories provide significant support to Headquarters staff in managing the activities of the total industrial program and to perform technical analyses as required. The Idaho National Engineering Laboratory, Argonne National Laboratory, Pacific Northwest Laboratory and the Oak Ridge National Laboratory are the principal participants in providing this support. Most of the management support is performed by Idaho National Laboratory which, through the Idaho Operations Office, evaluates proposals, monitors about 70 projects, prepares RFP's and conducts special studies as required. In addition analytical support is provided directly to Headquarters staff by selected contractors.

	FY 1985	FY 1986	FY 1987 Request
Industrial Cogeneration:	$ 5,116,000	$ 4,377,000	$ 1,500,000

The FY 1987 Congressional Budget Request is $1,500,000. This is $2,877,000 less than the FY 1986 Appropriation. The goal of Industrial Cogeneration is to encourage research on improved energy conversion systems to meet various industrial cogeneration requirements including systems with high electrical to thermal output ratios; advanced low voltage; high current direct conversion devices; characterization of organic Rankine cycle working fluids; and bottoming cycles development and evaluation.

The Industrial Cogeneration activities have been reduced from the FY 1986 planned activities. Work on the externally-fired Brayton system will be concluded at the end of FY 1986. The steam diesel development will continue but at a lower level of funding. Direct conversion work on thermionics will be concluded in FY 1987 although the sodium heat engine work will continue. Bottoming cycle research will be phased out in FY 1986 and not continued in FY 1987.

Advanced Topping Cycle Systems: Increased use of industrial cogeneration can be fostered through development of higher electrical-to-thermal output ratio systems than are yielded by standard steam turbine concepts. In addition development of technologies which utilize coal as a fuel permit flexibility of fuel choice. The development of innovative cogeneration systems will aid in meeting a projected growth for cogeneration of over 80,000 MW by the year 2000.

In FY 1986 the coal combustor topping tests were completed for the externally coal-fired Brayton system. Tests will also be conducted for waste fuels. A design study for a low temperature (1600°F) turbine will be started and an economic analysis made to compare the system with/without a topping combustor.

Activities on the coal-water fired "steam diesel" will be continued in FY 1986 and FY 1987. A parametric design of a full scale engineering test facility diesel engine will be completed in FY 1986 which would be used for long term testing of coal/water slurry fuels. In addition, installation design of a generic coal-water fired diesel will be accomplished in FY 1986 and an industry interaction group will be formed to review the test results and share in test engine planning. In FY 1987 the steam diesel study and laboratory testing of a laboratory scale steam diesel will be continued to determine engine wear rates. Additionally, laboratory tests will be conducted on coal slurry rheology to overcome limitations in pumping high coal ratio slurries to the engine.

Conversion of Thermal Energy to D.C. Electricity: Direct conversion devices, such as the thermionic diode and the sodium heat engine, may be able to cost-effectively meet some of industry's 5,000 megawatt requirement for relatively low voltage d.c. power used in electrolytic cells and other processes.

As a result of the laboratory work conducted in FY 1985 including an evaluation of the thermionic diode economics, the planned activity for FY 1986 will concentrate on the development of a larger size, more efficient diode. The larger units will be designed and laboratory prototypes built for testing in FY 1986. In addition, new approaches, including new materials and modes of operation, will be explored for improved output.

A 1,000 watt laboratory sodium heat engine will be designed and built with FY 1986 funds and laboratory tested in FY 1987. Performance of the unit will be evaluated against predicted performance and the effect of scale-up compared with a prior 200 watt model.

Bottoming Cycles Development: Increased performance of the low temperature waste heat driven organic Rankine cycle (ORC) could be achieved through the development of tailored organic fluids. Bottoming cycle cogeneration systems operating in the 700°F and higher temperature range would achieve widespread use if they were developed to be economically available. These systems could add another 4000 MW of electrical power generation and save 0.25 quad of energy annually.

In FY 1986, performance evaluation of a composite material BiPhase separator, will be completed. In addition, laboratory testing of selected ORC working fluids will be continued. Evaluation of these ORC fluids under realistic operating conditions will determine their limitations and permit modification or "tailoring" of the organic fluids to overcome these limitations for use in improved ORC systems.

	FY 1985	FY 1986	FY 1987 Request
Industrial Process Efficiency	$10,712,000	$19,551,000	$ 5,479,000

The FY 1987 Congressional Budget Request is $5,479,000. This is $14,072,000 less than the FY 1986 Appropriation.

The Industrial Process Efficiency subprogram supports activities which reduce the technical and economic risks which prevent industry from investing in more energy-efficient processes, technologies and practices. It cost-shares research and development activity which industry would not undertake on its own for a variety of reasons. The technical issues addressed vary significantly among projects. They include, for example, such matters as understanding basic chemical reactions; the investigation and specification of materials properties: testing and application of advanced microprocessor, laser and other technologies to improve the measurement of chemical and mechanical properties; and bench scale tests to determine feasibility of new processes. Projects undertaken are continued to the point where the combination of risk and return on investment will result in private sector investment.

R&D on steel processing, including thin slab and thin strip casting of steel will be concluded in 1986. The thin slab contract with U.S. Steel and Bethlehem will be stopped before procurement of pilot plant equipment. This will require specific legislative authorization, as the FY 1984 and FY 1985 approriations require DOE support of the technology through the pilot plant stage. FY 1987 funds will be for completion of tests on laboratory scale equipment, primarily the 17 inch wide horizontal twin belt caster. Further development of the single wheel casting approach will not be supported.

There will be a reduction of approximately two-thirds in research on more energy-efficient smelting of aluminum and termination of further work on development of dry coating technologies. With funds requested for FY 1987, investigations into and testing of electrode materials at Pacific Northwest Laboratories will be cut back and basic materials research at MIT will be terminated. Funding for further dry coating development at Georgia Tech is not included in the budget request. In the area of sensors, the FY 1987 request will support continuation of research started with prior year budgets; however, R&D on new sensors is not anticipated.

Priorities in the FY 1987 Congressional Budget Request include the following areas: (1) Process electrolysis; (2) Materials processing; (3) Sensors and controls; and (4) Separation systems.

Process Electrolysis: Products such as aluminum, magnesium, chromium, manganese and chlor-alkali are manufactured using the energy intensive electrolytic reduction process. Electrolysis requires more than 1.1 quads of energy annually to reduce alumina and magnesium, and to produce chlor-alkali. The energy use efficiencies are typically less than 50 percent. The industries potentially affected have been averse to spending significant amounts of limited capital on intensified research and development activity to reduce energy consumption.

In the aluminum industry, for example, DOE is sharing the developmental costs for technologies which could reduce the electrical requirements from 7 to 5.0 Kwh per pound or lower. New cathodes could provide a wettable surface to aluminum. By forming a very thin, even and non-surging coating of aluminum on the surface of the cathode, the anode-cathode spacing can be reduced. In addition,-candidate materials must possess excellent corrosion resistance to both aluminum and cryolite bath, with a high melting point which would enable them to withstand the elevated temperatures generated in the cell. Proprietary titanium diboride containing materials have been tested to date. Utilizing the experience gained to date and the laboratory equipment which has been developed, materials with varying compositions will continue to be tested.

Promising non-consumable anode and stable cathode materials have been developed. Testing and optimization are being undertaken. New methods of material application, resistant layer formation and attachment methods are being investigated. Success in these programs, combined with sensor development, will allow small scale testing in a self sustaining cell. Energy savings of approximately 25% are anticipated by the reduction of the anode-cathode distance. Additional energy savings will result from steady state operations over long periods of time with no anode change necessary. The most promising inert anode materials and fabrication techniques will continue to be tested. During FY 1987, additional work on selection and testing of candidate materials will be accomplished. Studies of bath chemical structure will be completed.

Materials Processing: A major change in steel processing is being investigated through two programs aimed at direct casting of thin steel slabs (.5 to 1.0 inch thick) or thin steel strip with thickness of approximately 0.050 inch. The potential energy savings associated with direct strip casting is 0.20 quad per year, based on avoidance of reheating, improved yield and less energy to roll a typical heavy cross section.

The thin slab program started in FY 1985, with initial work including feasibility studies, mathematical modeling of horizontal and vertical feeding designs, and construction/operation of a liquid steel test rig for horizontal machines. Parallel with this work was a major effort devoted to conceptual and detail design of a 17" horizontal twin belt casting machine, construction of which began in FY 1985.

In FY 1986 the testing of molten steel feeding systems will be made more rigorous by means of a 10 ton prototype system to test durability and performance of refractories. A smaller lab model of the vertical feeding design will be based on 2 tons of liquid steel throughput. Based on these tests, the final design of the feeding system is to be chosen by June 1986. The 17" horizontal simulator twin belt caster installation is scheduled for completion in April 1986, with start-up in June 1986. Extensive tests of laboratory scale casting systems will be performed during the first half of FY 1987. Product evaluation from these trials will be completed before choosing a casting direction for the pilot test unit. Work could then begin on a machine to produce thin slabs approximately 50 inches wide.

The second project on direct casting involves technology development of thin strip steel casting with a thickness of.050 inch. The effort in FY 1985 was devoted to design, construction and installation of a water cooled wheel caster for producing a strip 4" wide. In FY 1986 the machine will be operated to produce 500 lb batches of steel for proof-of-concept, concluding that activity.

Sensors and Controls: Industry has found energy and process efficiencies are greatly enhanced through the use of automatic process control systems based on use of computers. The petroleum refining and petrochemicals industries which operate multi-process integrated plants were early practitioners of integrated automatic control. As the pulp and paper, steel, food processing, textile finishing and other industries move toward automatic process control, they have found the lack of accurate, on-line sensors to measure process parameters to be a serious hindrance. A major limitation on the use of process control systems is the lack of appropriate sensors which will operate in the environmental extremes of many industrial processes.

In cooperation with industry, DOE has initiated programs designed to meet some of the needs for sensors in the steel, aluminum, pulp and paper, textile and food industries. During FY 1987, research on means to accomplish in-situ chemical analysis of molten steel will be completed. Development of sensors which measure the dissolved alumina content in molten electrolyte, as well as in-situ measurement of other chemical constituents of the electrolyte and its temperature, would improve aluminum industry efficiency, and will be addressed with the FY 1986 program.

In conjunction with the pulp and paper industry, projects underway include a program to improve the wet pressing operation in papermaking, as well as sensors to measure important parameters in black liquor combustion, steam flow, pulp consistency to the paper machine, and moisture content of paper in the dryer. A number of these sensors are also potentially applicable to the textile and food industries. In FY 1987 the most promising sensors will be tested in grain drying, textile mill, paper manufacturing and other industrial plants.

Separation Systems: A critical and energy intensive step in many industrial processes is the separation/concentration of one or more chemical components in a solution or mixture. Typically the operation is effected through thermal evaporation, distillation or drying. These unit operations are usually the most energy-consuming on any manufacturing site. Alternative technologies which can be used to perform the required operations are intrinsically less energy-intensive. Such methods include membrane separations; freeze concentration; solvent extraction; critical fluid extraction; advanced drying concepts and others. Engineering development and process research work are required to apply these energy-conserving technologies to a multitude of industrial process streams.

Estimates place annual industrial energy consumption for evaporation and distillation alone at 2.6 quads. In addition, large amounts of heat and reusable chemicals are also lost in industrial, contaminated, hot process wastewater streams because no adequate separation technology is available. Large quantities of energy are used to remove water from process streams, and large amounts of it are lost in contaminated hot process wastewater solutions. The highly specialized technologies required to reduce this energy consumption have applications in many industries, no one of which generally has the incentives and/or capital to perform the work on its own. Further, much of the innovative work is being conducted by small engineering companies and universities which do not have the research funds to devote to these applications.

During FY 1985 and prior years, laboratory development and testing programs have been carried out for a variety of freeze concentration and membrane concepts. During FY 1986, basic research leading to improved understanding of the drying process will be accomplished, and completion of bench-scale tests on hydride freeze applications in the food industry.

FY 1987 activities will include completion of on-site testing of membranes for organic stream separations, concentration of various foods and caustic solutions. Development will continue on advanced drying processes and black liquor combustion.

	FY 1985	FY 1986	FY 1987 Request
Implementation and Deployment:	$ 2,212,000	$ 2,978,000	$ 500,000

The FY 1987 Congressional Budget Request is $500,000. This is $2,478,000 less than the FY 1986 Appropriation.

The Implementation and Deployment program is characterized by a cooperative effort between government and industry to enhance industry awareness about the necessity of energy efficiency improvements and the cost effectiveness of investment in energy conservation. For a variety of reasons, an information gap often exists between the source of a technology and potential users. Significant energy savings are achievable if these gaps can be closed through an effective program of technology and information transfer.

The FY 1987 funding level requested results from the phase-out of: the industrial energy efficiency improvement reporting program and the Energy Analysis and Diagnostic Center energy audits for small manufacturers. For the reporting program, legislative repeal will be necessary to eliminate related statutory requirements of the Energy Policy and Conservation Act, as amended. FY 1987 funds will support scaled-back technology transfer activities, continuing to include technical seminars, symposia and publications.

Workshops and Seminars: This project provides cooperative support in the conduct of workshops, seminars and technical symposia on industrial energy conservation. Support may be provided for events both initiated and cosponsored by the DOE. Representative activities receiving past support have been the Industrial Energy Conservation Technology Conference and Exhibition sponsored by the Texas Public Utility Commission, and the World Engineering Conference held annually by the Association of Energy Engineers. Additional activities will be conducted as opportunities arise, having as their objective more effective technology transfer and improved energy productivity. Cooperative presentations will be made, on both specific technologies and general process improvements, with the major industrial trade associations and, as appropriate, national engineering and professional societies.

In FY 1987 support for selected industry, association and professional society conferences will continue at a reduced level. Targeted industry workshops and seminars will be conducted, with particular focus on technologies which have been developed with DOE support. These seminars will be implemented with the assistance of credible industrial associations and professional organizations. Attendees will be manufacturers and equipment producers who are in a position to make decisions which directly influence energy efficiency.

Publications: Information publication and dissemination are important elements of technology transfer. Publications concerning new and underutilized energy efficient technologies, with particular emphasis on those which have been developed with the assistance of the DOE, will be produced and distributed. These publications cover not only specific technologies but also address overall energy management for major industrial sectors.

With FY 1987 funds, development, review and publication of written materials, which provide information on projects sponsored by the DOE, will be accomplished. The specific publications will be determined by the status of individual projects and the nature of the intended audience. In general, publications will be produced with close cooperation and guidance from industrial associations, manufacturing corporations and/or professional engineering societies.

	FY 1985	FY 1986	FY 1987 Request
Program Direction:	$ 1,807,000	$ 2,016,000	$ 1,844,000

The FY 1987 Congressional Budget Request is $1,844,000. This is $172,000 less than the FY 1986 Appropriation. The request of $1,844,000 is for 26 full-time equivalent positions for conducting the program.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
TRANSPORTATION
ENERGY CONSERVATION

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Transportation (CE)					
Vehicle propulsion R&D:					
Operating expenses	$31,569	$32,085	$32,085	$ 6,500	$-25,585
Alternative fuels utilization:					
Operating expenses	2,430	1,489	1,489	1,260	-229
Electric and hybrid vehicle R&D:					
Operating expenses	8,349	8,586	8,586	4,140	-4,446
Transportation systems utilization:					
Operating expenses	1,650	887	887	0	-887
Advanced materials development:					
Operating expenses	6,021	8,646	8,646	6,500	-2,146
High temperature materials laboratory:					
Operating expenses	0	289	289	0	-289
Construction	6,469	2,515	2,515	0	-2,515
Subtotal	6,469	2,804	2,804	0	-2,804
Capital Equipment	2,940	0	0	0	0
Program direction					
Operating expenses	1,913	2,140	2,140	1,400	-740
Total					
Operating expenses	51,932	54,122	54,122	19,800	-34,322
Capital equipment	2,940	0	0	0	0
Construction	6,469	2,515	2,515	0	-2,515
Total, Transportation	$61,341	$56,637	$56,637	$19,800	$-36,837
Staffing Total FTE's	33	36	36	22	-14

Authorization: P.L. 93-577, "Federal Non-nuclear Energy Research and Development Act of 1974"
P.L. 93-275. "Federal Energy Administration Act of 1974"
P.L. 94-438, "Energy Reorganization Act of 1974"
P.L. 94-163, "Energy Policy and Conservation Act"
P.L. 94-413, "Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976"
P.L. 95-91, "Department of Energy Organization Act"
P.L. 95-238, "Department of Energy Authorizations for FY 1978"
P.L. 96-512, "Methane Transportation Research, Development and Demonstration Act of 1980"

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	Gramm-Rudman-Hollings Reduction	Adj. Approp. Total
Transportation						
Vehicle propulsion R&D						
Operating expenses...........	$34,470	$ -202	$ -741	$ ---	$ -1,442	$ 32,085
Electric and hybrid vehicle R&D						
Operating expenses...........	9,225	-55	-198	---	-386	8,586
Transportation systems utilization						
Operating expenses	950	-3	-20	---	-40	887
Alternative fuels utilization						
Operating expenses	1,600	-10	-34	---	-67	1,489
Advanced materials development						
Operating expenses	9,290	-56	-200	---	-388	8,646
Program direction						
Operating expenses	1,775	-10	-49	+521	-97	2,140
Capital equipment						
High temperature materials lab.						
Operating expenses...........	---	---	---	---	--	---
Construction	3,010	-15	-65	---	-126	2,804
Subtotal, Transportation ..	$60,320	$ -351	$-1,307	$ +521	$ -2,546	$ 56,637
General Reduction:						
Operating Expenses	$ -336	$ +336	$ ---	$ ---	$ ---	$ ---
Construction	-15	+15	---	---	---	---
Total, General Reduction ..	$ -351	$ +351	$ ---	$ ---	$ ---	$ ---
Management Initiatives:						
Operating Expenses	$-1,242	$ ---	$+1,242	$ ---	$ ---	$ ---
Construction	-65	---	+65	---	---	---
Total, Management Initiatives	$-1,307	$ ---	$+1,307	$ ---	$ ---	
Pay Restoration	+521	---	---	-521	---	---
Total, Transportation	$ 59,183	$ ---	$ ---	$ ---	$ -2,546	$ 56,637
Operating Expenses	$ 56,253	$ ---	$ ---	$ ---	$ -2,420	$ 53,833
Capital Equipment	--	---	---	---	---	---
Construction	2,930	---	---	---	-126	2,804

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
TRANSPORTATION
ENERGY CONSERVATION
(In thousands of dollars)

FY 1986 Appropriation enacted	$56,637
Program increases and decreases:	
Vehicle Propulsion R&D	
- complete proof-of-concept automotive gas turbine development	-13,957
- initiate follow-on gas turbine ceramic component development	+ 4,000
- conclude automotive Stirling engine development	-13,957
- continue adiabatic diesel research and development	- 291
- eliminate technology assessment and transfer activities	- 1,380
Subtotal	-25,585
Alternative Fuels Utilization	
- continue data collection and analysis of methanol-fueled vehicles	+ 220
- reduce synthetic fuels and conclude methane investigations	- 449
Subtotal	- 229
Electric and Hybrid Vehicle R&D	
- reduce battery R&D for EV application	- 1,025
- complete design phase only of ETX-II propulsion system	- 1,380
- eliminate data collection, site operator support, and test and analysis of vehicle technologies	- 1,925
- eliminate technology assessment and transfer activities	- 116
Subtotal	- 4,446
Transportation Systems Utilization	
- eliminate publication and distribution of *Gas Mileage Guide* and energy data collection and analysis	- 887
Advanced Materials Development	
- reduce R&D on structural ceramics for advanced heat engine application	- 2,146
High Temperature Materials Laboratory	
- funding for operational support included in Energy Research budget request under the Basic Energy Sciences Decision Unit	- 289
- complete funding requirements for HTML construction	- 2,515
Subtotal	- 2,804
Program Direction	
- reduce staffing level by 14 FTE	- 740
FY 1987 budget request	$19,800

Program Objectives and Strategy:

The objective of the transportation program is to perform research and development on vehicles and engines which will increase the fuel efficiency of the transportation system and allow a switch from petroleum to electricity and alternative fuels. The strategies used to achieve these objectives are to: (1) establish proofs-of-concepts for advanced engine technology that have at least a 30 percent improvement in fuel efficiency over comparable conventional engines, meet emission, safety, and noise standards, have alternative fuels capability, and have competitive production costs; (2) develop technology for heavy duty diesel operation under uncooled and minimum friction conditions, having the potential of 30-40 percent fuel economy improvement over 1982 technology; (3) advance battery and propulsion system technology for competitive electric and hybrid vehicles for passenger car, van, or light truck application; (4) establish a fundamental ceramic and advanced materials technology base for heat engines; and (5) develop a utilization-oriented data base on switching from petroleum to fuels made from oil shale, coal, and biomass.

Accomplishments for FY 1985 and anticipated accomplishments for FY 1986:

o Operated ceramic turbine rotors up to 100 percent of engine design speeds in both the AGT-100 and the AGT-101 at reduced temperatures and power.

o Completed rig qualifications of AGT-101 ceramic static components at design temperature of 2500°F.

o Completed successful operation of the AGT-100 low-emission, pilotless ceramic combustor over the full engine design range.

o Completed design of the MOD II Stirling engine and initiated procurement of long leadtime hardware.

o Completed over 10,000 hours of engine test time on the MOD I Stirling engine design.

o Completed fabrication of first generation ceramic coated piston rings for adiabatic diesel evaluation.

o Completed characterization of friction and wear properties of candidate ceramic materials for use in adiabatic diesel piston ring and cylinder liner applications.

o Completed the development of an advanced single-shaft a.c. powertrain including installation in a test bed vehicle and dynamometer testing on the Federal Urban Driving Cycle with an experimental zinc-bromine battery.

o Completed the preliminary design and mission analysis for the dual-shaft a.c. propulsion system for an electric van application incorporating nickel-iron battery and field-oriented control electronics.

o Completed module development and battery subsystem design for advanced tubular-plate and sodium-sulfur technologies.

o Completed characterization testing of the GM Bedford electric vans and the Eaton a.c. propulsion system at the Idaho National Engineering Laboratory.

o Completed field test evaluations of battery thermal management systems, nickel-zinc battery systems, state-of-charge meters and the battery watering wand that demonstrated a reduction in watering time of up to 75 percent.

o Published and distributed approximately 3,000,000 copies of the 1985 model year Gas Mileage Guide.

- o Initiated introduction of methanol-fueled vehicles into the Federal fleet and established data collection and support procedures.
- o Completed first-phase research effort to determine substitution for cetane method in measurement and specification of ignition quality with synthetic fuels.
- o Completed development of a low thermal conductivity silicon carbide whisker reinforced mullite ceramic composite with greatly improved strength and toughness.
- o Completed development of ceramics-to-metal brazing techniques with application to piston cap and turbine/rotor shaft attachments.
- o Completed development of techniques for sol-gel coating of ceramic whiskers to enhance matrix/whisker interfacial properties.
- o Completed development of a transformation toughened ceramic alloy capable of long time 1,000°C operation.
- o Completed construction of the High Temperature Materials Laboratory at ORNL (end of FY 1986 or early FY 1987).

Vehicle Propulsion R&D .... $ 6,500,000

The Vehicle Propulsion R&D FY 1987 budget request is $25,585,000 less than the adjusted FY 1986 Apropriation for these activities. The proof-of-concept Automotive Gas Turbine Program is scheduled to be completed in FY 1986, and the FY 1987 request includes the initiation of a less costly follow-on program for component development. The proof-of-concept Automotive Stirling Engine Program will be concluded in FY 1986, and no funding will be required in FY 1987. The Heavy Duty Transport Program, focused on the adiabatic diesel, will essentially continue at FY 1986 levels. The Technology Assessment and Transfer activities will be eliminated as separate activities in FY 1987. Technology transfer will be achieved through the industry involvement in specific program areas.

The goal of the Vehicle Propulsion R&D program is to encourage development within the automotive industry of more fuel-efficient, fuel-flexible and cost-effective transportation heat engine propulsion system options through support of research and development on technological barriers and proofs-of-concepts.

The technical objectives of the Vehicle Propulsion R&D program are: (1) achieving at least a 30 percent improvement in fuel economy over conventional heat engines, (2) meeting or exceeding established requirements for regulated emission levels, and (3) operating satisfactorily on a wide variety of fuels. To accomplish these objectives, research and development has been pursued on advanced heat engine concepts including the automotive gas turbine, the automotive Stirling engine, and the heavy duty adiabatic (uncooled, minimum friction) diesel engine. Common to the needs of all advanced heat engine concepts is the requirement to develop improved high-temperature materials and components.

The FY 1987 funding is necessary to allow continuation of the research and development activities required to establish an industry technology base on high-temperature, uncooled, minimum friction diesel engines. An uncooled, or adiabatic, heavy duty diesel engine integrated with a waste heat recovery technique has the potential for efficiency improvements in the 30 to 40 percent range. An industry assessment has provided identification of the technological barriers, and a phased development approach has been designed. The request will fund planned activities in ceramic component evaluations in a single-cylinder, uncooled engine; performance analyses of a baseline adiabatic diesel design; initial experimental emissions evaluations; upper-cylinder interface analyses and evaluations; and high-temperature engine heat transfer computer models. The funding will also provide for a follow-on program to continue ceramic component development for an automotive gas turbine engine. Although the Automotive Gas Turbine program (AGT), to be completed in FY 1986, will demonstrate the feasibility of the engine concept, further research and development on ceramic components processing and reliability is required before industry will consider the engine for commercialization. The program will utilize engines fabricated under the AGT program for test beds, and basic ceramic technology research results from the Advanced Materials Development program for improved component fabrication and evaluation. The Automotive Stirling Engine (ASE) Program will be concluded in FY 1986, and program results and experimental engines will be made available to industry.

Alternative Fuels Utilization .... $ 1,260,000

The FY 1987 budget request for Alternative Fuels Utilization is $229,000 less than the adjusted FY 1986 Appropriation but essentially covers a continuation of FY 1986 activities. Funding is included for continuing data collection and analysis on Federal fleet methanol-fueled vehicles which was funded in FY 1986 with unexpended prior year obligations. Research and development projects on synthetic fuels utilization are stretched out. Investigations on methane utilization will be concluded in FY 1986.

The goal of the Alternative Fuels Utilization program is to accelerate the introduction of nonpetroleum-based transportation fuels by establishing a technology base for utilization of synthetic, biomass-derived, and gaseous fuels in both contemporary and advanced propulsion systems.

The FY 1987 funding is necessary to allow continuation of research and development activities focused on performance, emissions, optimization and wear characteristics of conventional and advanced engines using synthetic fuels derived from oil shale and coal syncrudes. Tests and evaluations are conducted on both single-cylinder and multi-cylinder engines, and the program will continue to provide industry and the scientific community with standardized synthetic test fuels. The funding will also allow continuation of the collection and analysis of data from the methanol-fueled vehicles operated as part of the Federal fleet.

Electric and Hybrid Vehicle R&D .... $ 4,140,000

The Electric and Hybrid Vehicle R&D FY 1987 budget request is $4,446,000 less than the adjusted FY 1986 Appropriation for these activities. A major change in the FY 1987 request is due to the decision to complete the design phase only of the second-generation, single-shaft a.c. propulsion system (ETX-II) with termination of hardware fabrication. The development of the dual-shaft a.c. propulsion system will be continued in FY 1987 but at a lower level of effort and an extension of the schedule. Three final battery candidates will be selected from the six under development in FY 1986 for further development in FY 1987. Site operation testing, field evaluation, and data collection and analysis of available battery and drivetrain component technologies will be concluded and laboratory testing phased out in FY 1987. The data base results will be published and made available to industry developers. Technology assessment and transfer activities will be eliminated as a separate activity in FY 1987. Substantial industry participation in the development activities will provide effective technology transfer in current technology areas.

The goal of the Electric and Hybrid Vehicle program is to develop the technology in cooperation with industry that will lead to the production and introduction of electric vehicles into the Nation's transportation fleet and substitute more abundant sources of energy for petroleum-based fuels.

The FY 1987 funding is necessary to continue the development of an advanced lead-acid battery technology based on the flow-through electrolyte concept for improved energy density, sustained power density and longer life. The request will fund the continuation of development of the promising sodium-sulfur and zinc-bromine battery technologies for the electric vehicle application including thermal management and system optimization. Funding is necessary to continue development of the advanced dual-shaft propulsion system technology, including the integration of nickel-iron battery technology, towards a level of maturity that will allow industry to make a quality decision regarding its viability.

Transportation Systems Utilization .... $ 0

No funds are being requested for the publication and distribution of the Gas Mileage Guide. Gas mileage information is required on the stickers of all new cars. DOE will submit a legislative initiative to remove the mandatory printing and distribution of the Guide. DOE will encourage the private sector (automobile publications and newspapers) to print the fuel economy information when it is released each new model year by the Environmental Protection Agency. This approach is capable of reaching a much wider audience than DOE publication of the Guide.

The collection, analysis, and presentation of transportation energy data in the Transportation Energy Data Book will not be continued. DOE will rely on the private sector to provide analysis of current energy usage and projections of transportation activity and energy use.

Advanced Materials Development .... $ 6,500,000

The FY 1987 budget request for Advanced Materials Development is $2,146,000 less than the adjusted FY 1986 Appropriation for similar activities. The decrease results from focusing the materials effort onto the highest-payoff areas and making effective use of the new High Temperature Materials Laboratory where such efforts are being consolidated.

The goal of the Advanced Materials Development program is to develop an industrial technology base in structural ceramics, ceramic composites, and coatings capable of providing reliable and cost-effective components for high-temperature, efficient transportation propulsion systems while eliminating requirements for scarce strategic materials.

The efficiency and economics of advanced heat engines are materials limited, and utilization of high-temperature ceramic components and coatings is a key technology need. Although ceramics have demonstrated the potential temperature and environmental resistance capabilities necessary, substantial research is required to achieve adequate strength, toughness, and other specific properties needed before reliable ceramic components can be produced commercially. The technology developed within the program, as well as the availability of the High Temperature Materials Laboratory being constructed under the program at Oak Ridge National Laboratory, will have significant spinoffs for increasing the efficiency and productivity of a wide range of other industrial applications in addition to transportation.

The funding in the FY 1987 request is necessary to continue phased activities on existing contracts and research projects and initiate some new research projects essentially in accordance with a limited stretch-out of the Ceramic Technology for Advanced Heat Engines Program Plan. The program activities will include projects on materials and processing of monolithic silicon nitride and silicon carbide, oxide matrix and dispersion toughened composites, thermal and wear zirconia-based coatings, and ceramic-to-metal and ceramic-to-ceramic joining; materials design methodology for dynamic interfaces; data base/life prediction for time dependent behavior; IEA Standardization; and program management and coordination.

High Temperature Materials Laboratory .... $ 0

The FY 1987 budget request does not include funding for the High Temperature Materials Laboratory (HTML) since the final increment of required construction funds was appropriated in FY 1986. During FY 1987 the HTML will initiate operations, and begin placement of personnel for the permanent User Staff. Based on the fundamental and cross cutting nature of the operations to be conducted at the HTML, funding for the operational research staff will be included in the Basic Energy Sciences budget of the Office of Energy Research beginning in FY 1987. The Transportation Appropriation for FY 1986 included funding for pre-operational support during construction of the HTML, and this change plus the completion of construction funding accounts for a total reduced need of $2,804,000 from FY 1986.

Program Direction .... $ 1,400,000

The FY 1987 budget request for Program Direction is $740,000 less than the adjusted FY 1986 Appropriation, as a result of a reduction of 14 FTE positions. The funds requested provide for 22 FTE positions to develop strategies, plans and resource requirements, and provide the integrated program management necessary to conduct the research and development of the various transportation technologies described in the budget request.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
ENERGY CONSERVATION
MULTI-SECTOR
LEAD TABLE

(Tabular Dollars In Thousands. Narrative Material In Whole Dollars)

	FY 1985 Appro- priation	FY 1986 Appro- priation	FY 1987 Base	FY 1987 Request	Request Vs Base
Multi Sector (CE)					
National Appropriation Technology and Assistance Service					
Operating Expenses.............	$ 1,470	$ 1,396	$ 1,396	$ 750	$ -646
Capital Equipment..............	---	---	---	---	---
Subtotal......................	$ 1,470	$ 1,396	$ 1,396	$ 750	$ -646
Energy Related Inventions Program					
Operating Expenses.............	$ 4,900	$ 4,653	$ 4,653	$ 3,300	$-1,353
Capital Equipment..............	---	---	---	---	---
Subtotal......................	$ 4,900	$ 4,653	$ 4,653	$ 3,300	$-1,353
Energy Conversion and Utilization Technologies					
Operating Expenses.............	$15,463	$18,097	$18,097	$15,200	$-2,897
Capital Equipment..............	1,666	930	930	100	-830
Subtotal......................	$17,129	$19,027	$19,027	$15,300	$-3,727
Program Direction (ECUT)					
Operating Expenses.............	$ 292	$ 498	$ 498	$ 500	$ +2
Subtotal......................	$ 292	$ 498	$ 498	$ 500	$ +2
Total					
Operating Expenses.............	$22,125	$24,644	$24,644	$19,750	$+4,894
Capital Equipment..............	1,666	930	930	100	-830
Subtotal......................	$23,791	$25,574	$25,574	$19,850	$-5,724
Total, Multi-Sector................	$23,791	$25,574	$25,574	$19,850	$-5,724
Total FTE's......................	4*	9*	9*	8*	-1

Authorization: P.L. 93-577, Federal Nonnuclear Research and Development Act of 1974.
P.L. 95-91, Department of Energy Organization Act.

*FTE and associated costs are for Energy Conversion and Utilization Technologies only.

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Gramm-Rudman-Hollings Reduction	Adj. Approp. Total
Multi-Sector (CE)					
National Appropriate Technology and Assistance Service					
Operating Expenses	$ 1,500	$ -9	$ -32	$ -63	$ 1,396
Energy Related Inventions Program					
Operating Expenses	5,000	-30	-108	-209	4,653
Energy Conversion and Utilization Technologies					
Operating Expenses	19,440	-112	-418	-813	18,097
Capital Equipment	1,000	-6	-22	-42	930
Subtotal	$20,440	$ -118	$ -440	$ -855	$19,027
Program Direction (ECUT)..........	535	-3	-12	-22	498
Subtotal, Multi-Sector	$27,475	$ -160	$ -592	$-1,149	$25,574
General Reduction:					
Operating Expenses	$ -154	$ +154	$ ---	$ ---	$ ---
Capital Equipment	-6	+6	---	---	---
Total, General Reduction.....	$ -160	$ +160	$ ---	$ ---	$ ---
Management Initiatives:					
Operating Expenses	$ -570	$ ---	$ +570	$ ---	$ ---
Capital Equipment	-22	---	+22	---	---
Total, Management Initiatives	$ -592	$ ---	$ +592	$ ---	$ ---
Total, Multi-Sector (CE)......	$26,723	$ ---	$ ---	$-1,149	$25,574
Operating Expenses	$25,751	$ ---	$ ---	$-1,107	$24,644
Capital Equipment	972	---	---	-42	930

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
ENERGY CONSERVATION
MULTI-SECTOR
(in thousands of dollars)

FY 1986 Appropriation enacted	$25,574
Program increases and decreases:	
Energy Conversion and Utilization Technologies	
Combustion and Thermal Sciences:	
Eliminate research on microemulsion fuels technology, advanced heat transfer, and direct contact heat exchanger	-1,226
Materials:	
Maintain level of effort in high-temperature materials and materials-by-design research; terminate research on lightweight and corrosion-resistant materials	-184
Catalysis/Biocatalysis:	
Terminate research on direct use off enzymes in biochemical reactors and in catalysis-by-design	-192
Tribology:	
Eliminate research on mechanisms of friction and wear of ceramics and reduce level of effort in lubricants, tribological coatings, and data retrieval system	-1,355
International Research Monitoring:	
Maintain minimum level of tracking international energy conservation research	-40
Conservation Program Analysis and Planning:	
Initiate Conservation program oversight and long-range planning activity	+100
Energy-Related Inventions Program	
Reduce number of grants awarded by DOE for ERIP	-1,353
National Appropriate Technology and Assistance Service	
Reduce funding for NATAS	-646
Capital Equipment	
Reduce capital equipment for national laboratories and Historically Black Colleges and Universities	-830
Program Direction	
Reduce number of FTE's for ECUT from 9 to 8	+2
FY 1987 budget request	$19,850

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DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW
Energy Conservation - Multi-Sector

This request is for $19,850,000 for the Multi-Sector Conservation Program: $15,300,000 for the Energy Conversion and Utilization Technologies (ECUT) Program, $3,300,000 for the Energy-Related Inventions Program (ERIP), and $750,000 for the National Appropriate Technology Assistance Service (NATAS).

Energy Conversion and Utilization Technologies

The primary mission of the Energy Conversion and Utilization Technologies (ECUT) Program is to expand and solidify the generic technology base that supports initiatives by both the DOE end-use Conservation programs and U.S. private industry to improve the efficiency of energy conversion and utilization systems. ECUT research is aimed at understanding and improving techniques, processes, and materials that push the thermodynamic efficiency of energy conversion and usage beyond the state-of-the-art. ECUT also assesses the current state of energy conservation technologies in foreign countries to provide a comparative assessment of U.S. efforts in important conservation technologies.

There are four distinguishing features of ECUT research compared to other Department research programs: (1) it is a program of directed basic research (problem oriented) that anticipates future end-use sector needs, (2) it focuses on solving problems that may be common to more than one energy-consuming sector (for example, understanding combustion phenomena), (3) it makes a concerted effort to seek out, encourage, and support new ideas and concepts, and (4) it provides predictive models and design tools for use by the private sector to improve designs, to scale (up and down) processes, and to create new hardware aimed at achieving increased energy productivity.

ECUT currently conducts programs in four interdisciplinary research areas: Combustion and Thermal Sciences, Materials, Biocatalysis, and Tribology. Each of these activities contributes to accomplishing the following goals:

- Establish the feasibility of revolutionary concepts that offer the potential for significantly reducing energy consumption in energy conversion processes and energy end-use.
- Monitor advances in research and engineering both in the United States and abroad, and evaluate them for applicability to energy conservation.
- Carry out exploratory development on novel or innovative conservation concepts.
- Expand and place on firm footing the technology base for energy conservation technologies.
- Ensure a continual flow of information on new conservation-related technical advances to the DOE end-use sector Conservation programs and to private industry.

ECUT accomplishments for FY 1985 and anticipated accomplishments for FY 1986:

- Successfully used simplified engine experiments, flow reactor studies and real engine tests to develop and validate a comprehensive chemical kinetics model for simple fuels to study engine knock. Gained insight essential to the development of environmentally safe additives or to devise more effective fuel-blending strategies.
- Found differences in the low-temperature ignition kinetics of alternative fuels that were not evident in the traditional American Society for Testing and Materials (ASTM) cetane rating procedure. The experimental technique, which was co-funded by ECUT and the Office of Transportation Programs, provided insight

into fuel characteristics which are essential to improving the ignition and combustion properties of broad-specification fuels.

- Successfully obtained the first two-dimensional measurements of the structure of a propagating turbulent flame in an operating internal combustion engine, thus providing an essential input to the development of physically realistic, predictive models of flame propagation in engines.

- Completed first experiments using ECUT Reversing Flow Test Facility to develop performance profiles of annular regenerators. These efforts were conducted in cooperation with the Office of Buildings and Community Systems and the Office of Transportation Systems in support of the development of Stirling engine and heat pump technologies.

- Developed heat exchanger vibration analysis for accurate prediction of tube bundle instabilities. The computerized analysis capability can now be used by designers to predict the internal crossflow field for each tube in a tube bundle and to identify those tubes most likely to experience fluid elastic instability, together with the instability vibration mode.

- Licensed Ni_3Al alloy technology to Cummins Engine Company for development and use as combustion chamber materials for truck diesel engines.

- Identified an ordered metallic alloy with high-temperature (2,000°C) capabilities potentially rivaling those of ceramics.

- Filed two patent applications and one patent disclosure as result of ECUT work on reactive metal brazes to join ceramics to ceramics and/or to metals. Private industry is now showing interest.

- Developed SiC whisker reinforced Al_2O_3 ceramic composite cited by Science Digest as one of the top innovations of 1985. This composite is now being sold commercially by Greenleaf Corp. for use in cutting tools.

- Completed research which first showed feasibility of producing ceramic powders ina rotary kiln. Advanced Refractory Technology (ART), Inc. is now marketing SiC ceramic powders produced in this manner.

- Completed development of models which predict effects of aging on rigid urethane foam insulation. This has enabled Mobay Chemical and Jim Walker Corp. (Manufactured Homes) to apply these models to make better insultating foam, i.e. foam which is more stable and has a higher R-value.

- Discovered a new ductile ordered metallic alloy based on magnesium.

- Designed selective inhibitors and immobilization systems for enzymes (e.g. thermolysin) using ECUT-developed predictive models. This is important because enzymes generally lose their catalytic activity when they are tied down (immobilized).

- Demonstrated in laboratory experiments a new technique to stabilize genetic information in microorganisms. This is important because the genetic information engineered into microorganisms by the usual recombinant DNA techniques tends not to get transferred when the microorganism reproduces.

- Demonstrated a bioreactor concept that used a hydrogen gas atmosphere (as opposed to the usual oxygen environment) to increase process efficiency and product specificity.

- Demonstrated a bioreactor concept having an 80-fold increase in productivity over that of a conventional fermenter.

- Showed in laboratory experiments that a novel method of delivering elevated temperature (200^{0}-600^{0}C) lubricants from the gas phase is a workable method for lubricating machinery at these temperatures. Similar work in powdered lubricants, which offers the same promise of delivering lubricants exactly when needed, may solve some of the lubrication problems of advanced engines.

- Determined the amount of hard coatings necessary for industry to systematically implant tribological coatings for cams, gears, toolbits, etc., in order to impart less expensive substrate materials with more desireable friction and wear properties. These coatings are more than 10 times harder and only 20 percent greater in cost than state-of-the-art coatings available today.

- Established a prototype computerized data retrieval and information system that will provide the scientific and engineering community with up-to-date tribological data and information. This system will enable engine designers, for example, to manipulate mathematical models from many different sources at their work stations in a user-friendly manner. Jointly sponsored by a whole host of professional societies, this system is the first of its kind in the United States and is the result of international cooperation with Canada and West Germany.

Energy Conversion and Utilization Technologies................................$15,300,000

This request is to provide funds to expand the technology base for the Conservation program. Funding of $15,200,000 is requested for the following research areas: Combustion and Thermal Sciences, Materials, Biocatalysis, and Tribology, along with $100,000 in capital equipment for research instrumentation.

Combustion and Thermal Sciences $4,800,000

The FY 1987 request for Combustion and Thermal Sciences is $4,800,000, a reduction of $1,226,000 from the FY 1986 appropriation.

Combustion and Thermal Sciences

The ECUT Combustion Technology Research Program was established to promote the design and development of energy-conserving combustion systems and devices. Since combustion is the fundamental process for converting fuels into usable energy, improved understanding can yield significant benefits in virtually all end-use applications. Research in this program is focused to study problems associated with the development and evolution of comprehensive predictive capabilities for combustion systems.

The technical objective of the Combustion Technology Research activity is to provide a set of proven analysis and measurement techniques and a better understanding of combustion and combustion-related processes for intermittent and continuous combustion systems and devices. The ECUT activities are structured to ensure the usefulness and availability of these capabilities to designers of engines in industry. Laser-based diagnostics and multidimensional computations are used to investigate precombustion fluid motion, fuel preparation, sprays and turbulence in combustion, and emission formation mechanisms. Research groups, which include DOE national laboratories and university and industrial researchers, convene periodically to study specific combustion-related problems in engines as well as stationary combustors. Activities are designed to bridge the gap between basic research and engineering development phases of technology development. In addition, investigations of innovative combustion system concepts are conducted, e.g. pulse combustion systems and other concepts that are specially designed to improve system efficiency and fuel flexibility. Through the International Energy Agency, the Combustion Technology Research Program collaborates with the major energy consumers of the free world.

The technical outputs of the ECUT Combustion Technology Research Program include proven advanced diagnostic techniques, experimental data, validated computer models, innovative concepts, state-of-the-art technologies and expanded scientific and technical knowledge.

The FY 1987 funding includes resources to continue activities in Engine Combustion Technology and in Continuous Combustion Technology projects. Through close interaction with industry, ECUT focuses research which has been identified as essential to the development and improvement of advanced engine concepts. These concepts are devised to improve fuel economy and enhance the ability of internal combustion engines to use alternative fuels without compromising established emission requirements. Efforts are further encouraged via an annual token cost-share from the Motor Vehicle Manufacturers Association (MVMA) to support the application of advanced diagnostic techniques. The following is a description of each project for FY 1987:

Engine Combustion Technology

The Engine Combustion Technology research project will focus on:

(1) Events that are believed to promote the occurrence of engine "knock" in dilute homogeneous-charge and direct injection stratified-charge engines. Engine knock limits an increase in compression ratio that can improve thermal efficiency of an engine and thus decrease fuel consumption. Engine knock phenomena will be investigated by examining the nature of the chemical processes and the fluid mechanics prior to, during, and just after the event. This will permit research to impact both the needs of the fuel supplier as well as those of the engine designers.

(2) Fluid mechanics/combustion interactions in internal combustion engines with particular emphasis on the importance of turbulence in the combustion process. The behavior of internal combustion engines is greatly influenced by the fluid motion in the intake manifold and within the cylinder. In-cylinder processes that govern engine performance, such as mixing, combustion, and heat transfer, are to a great extent controlled by the turbulence and bulk fluid motions.

(3) The role of sprays in diesel engine combustion with special emphasis on mixing rate of the charge air and fuel, soot formation, and emissions. The importance of emission and particulate mitigation cannot be overstated. While significant improve-ments have been realized in recent years, automobiles continue to be the largest single source of air pollution in the world today. In addition, this research will provide insight into the feasibility of multi-fuel use in such innovative concepts as pulse combustors.

(4) The role of in-cylinder convection and radiation heat transfer on engine operating efficiency. Heat losses generally account for an estimated 60 percent of the difference between ideal fuel-air cycle efficiency and indicated efficiency which translates to a 5 percent reduction in engine efficiency due to heat losses. Understanding the relationship of the various processes of heat transfer in engines will lead to a reduction of this heat loss quantity. An efficiency gain of approximately 3 percent appears attainable.

Continuous Combustion Technology

The Continuous Combustion Technology research project will continue to focus on enhancing the understanding of and providing experimentally validated analytical capabilities for spray and turbulent combustion, advanced combustion concepts, and corrosion/erosion of combustor components. In addition, special projects with relevance to enhancing the feasibility of combustion technology are pursued. These areas are described below:

(1) Spray and turbulent combustion. The ECUT program couples experimental investigations of particulates and fuel droplets with spray combustion modeling activities to study the effects of structure and physical properties of fuel on combustion. In the combustion of fuel-oil sprays, the liquid fuel drops change

into carbonaceous porous sphere-like particles called cenospheres. These cenospheres burn and the products determine the majority of the deposits found on metal surfaces, promoting corrosion/erosion. Trace compounds existing in the initial fuel drop have a much higher concentration in the cenospheres than in the original fuel. Therefore, work will be continued toward the development of a dense spray computer model which will include the formation and subsequent combustion of the cenospheres.

(2) Advanced combustion concepts. Research will continue in the area of pulse combustion. Pulse combustion is a process by which combustion of fuels is driven by self-sustained oscillations. Pulse combustors have been built in a variety of sizes and shapes and have been fired with oil, gas, and coal. However, acceptance and development of pulse combustion systems have been hindered by high noise levels and the complex underlying theory of their operation. Small changes in configuration have significant effects on performance. Designs have evolved more by trial and error and from empirical correlations than from the application of basic principles. The high combustion intensity, minimal standby losses, and potential for superior heat transfer make pulse combustion a very desirable energy-conserving technology. The coupling of experiments and modeling activities will allow for a more complete analysis capability than combustion that has been limited to natural gas as a fuel. FY 1987 efforts will continue to investigate the effect of liquid and solid fuels on the operating parameters and therefore on the performance and emissions of pulse combustion. Research will couple the apparent basic principles of combustion and heat transfer processes.

Thermal Sciences

The objective of the Thermal Sciences activity is to provide a comprehensive technology data base for use by industry to design and further the development of conversion systems and devices with enhanced performance and reliability over those currently available. Applied and exploratory research is undertaken to develop experimentally validated analysis and computerized data bases necessary to strengthen the private sector's design and development abilities.

The FY 1987 Thermal Sciences research activity will continue to serve as the focus for the relevant needs of advanced conversion system development, responding to the needs of both the private sector as well as those of the DOE and other Government-sponsored programs. Efforts are closely collaborated with industry, universities, the DOE national laboratories, and other Government-sponsored researchers. Cooperative activities are underway with the Gas Research Institute (GRI) and the DOE Buildings and Community Systems and the Transportation Programs. In addition, there is International Energy Agency collaboration in Heat Transfer and Heat Exchangers involving six participants from the free world.

In the Thermal Sciences activities, a comprehensive experimental program was initiated in FY 1985 to exploit the capabilities of the specially designed Reversing Flow Test Facility (RFTF). The RFTF is the first-of-a-kind in the United States. It was designed as an experimental facility to study the aspects of energy conversion cycles with the ability to simulate real cycle processes, in particular those characterized and affected by reversing, or oscillating, flow conditions. This effort was continued in FY 1986 to study the thermodynamics and fluid dynamics in major components of closed-cycle systems and to validate analysis methodologies currently being developed. FY 1987 activities will complete the development of improved general purpose computer models for analysis and optimization for use in the design of advanced energy conversion systems that employ such closed-cycle designs as free piston and kinematic Stirling engine systems. The experimental results from the RFTF will be used to accurately validate these and other such computer models.

The initial research for the RFTF was started in FY 1985 to investigate the aspects of regenerator theory as it relates to performance for real systems. Continued in FY 1986, this effort has undertaken to examine flow maldistribution problems apparent in Stirling engine regenerator designs. Recent analyses of annular regenerators such as those used in free-piston and automotive Stirling engine designs have revealed the possibility that these maldistribution problems contribute to heat conduction losses, resulting in low efficiency operation. In addition, there continue to exist unexplained differences between theory and actual practice which are believed to contribute significantly to heat transfer-related inefficiencies evident in energy conversion systems. These differences are believed to be due primarily to inaccurate estimations of pressure drop for flows through complex channels and a lack of adequate understanding of actual flow conditions, i.e. steady vs. unsteady flow conditions. The continuing research focuses on the identification of controlling mechanisms in regenerator flows, with an objective to establish specific guidance for regenerator design.

Materials $5,400,000

The FY 1987 Request for the ECUT Materials Project is $5,400,000, a decrease of $184,000 from the FY 1986 appropriation.

The ECUT Materials Project seeks to identify and develop new materials and processing concepts of potential use to energy conservation. ECUT monitors and picks up on the wealth of research opportunities coming out of basic research programs, particularly those funded by the DOE Office of Basic Energy Sciences and the National Science Foundation. ECUT develops sufficient data on the properties and performance characteristics of these materials and processing concepts and conducts research to improve them to the point that either an end-use program or industrial firm will undertake engineering development or make use of the new material in its components, devices, or systems.

The requested level of FY 1987 funding is necessary to maintain most research currently underway in the areas of high-temperature materials and materials-by-design. Research on lightweight materials and corrosion resistant materials will be terminated.

High-Temperature Materials

ECUT high-temperature materials research currently underway will be continued in FY 1987 for the following:

- Ductile Ordered Metallic Alloys
- Ceramic Attachments
- Ceramic Materials.

Ductile Ordered Metallic Alloys: Metallic materials with ordered atomic structures such as long-range ordered (LRO) and intermetallic alloys have not been utilized until now despite their potential for superior performance (e.g., four times the yield strength of conventional materials at elevated temperatures) due to their characteristic brittleness. These high-temperature materials have the unusual property of increasing in strength with increasing temperature and can withstand other severe operating conditions, such as corrosive environments.

ECUT research is focused on the initial measurement and improvement of engineering properties (yield strength, ductility, creep, fracture toughness, etc.) of these materials needed by designers of future high-performance energy conservation concepts and on delineating the limits of improvability of these properties.

In early 1982, after more than 30 years of failure by numerous researchers, a breakthrough was achieved at Oak Ridge National Laboratory in the ability to make one member of the family of intermetallic compounds, nickel aluminide (Ni_3A), highly ductile (on the order of 50%). ECUT immediately provided the major funding necessary to capitalize on this basic research breakthrough and began to support the characterization and improvement of this material. This research will continue in FY 1987.

Like the LRO alloys, the ordered intermetallics increase in strength with increasing temperature. Presently this yield strength increases up to a certain point and then begins a gradual decline. However, no reason has yet been found why this strength should not continue to increase right up to the decomposition temperature which far exceeds 1000°C. In FY 1987 ECUT will continue research toward understanding this mechanism of increased temperature stability in nickel aluminide and applying this knowledge to other members of the intermetallic family of alloys, such as aluminides of titanium, iron, and magnesium, to name just a few.

Ceramic Attachments: ECUT ceramic joining work seeks to ensure the availability of methods to join ceramic components together whenever they can be manufactured. Such techniques are important because they will allow ceramic components to be used economically in large operational systems such as heat engines and heat exchangers.

ECUT research aims to increase the understanding of the problems and limitations inherent in joining and bonding ceramics to ceramics and ceramics to metals. In FY 1987, joining ceramic materials by means of microwave heating and verification of the residual stress finite element predictive models for both brazed and unbrazed joints for five basic joint geometries will be continued. Work to understand and model interfacial phenomena important in ceramic attachment also will be continued.

Ceramic Materials: Ceramic materials fail catastrophically through the growth and propagation of defects, particularly cracks initiated at free surfaces. The principles behind methods of toughening are to reduce the size and number of defects and to provide in the ceramic matrix a secondary phase that can absorb the crack propagation energy and arrest it. In the case of transformation toughening, a minor phase absorbs the energy by undergoing a diffusionless phase transformation to a higher energy but nevertheless stable phase. In the case of compositing approaches, a minor phase such as a fiber with some ductility is provided to absorb the energy by elastic and plastic deformation.

In FY 1987 ECUT will continue investigating the reasons for the brittleness of ceramics and will continue researching methods to toughen them by compositing and modifying their surfaces by ion implantation and other techniques. In addition, novel techniques for producing near net shape ceramic samples will be pursued.

Compositing will include combining various ceramics with the LRO alloys and/or aluminide materials discussed above. These efforts could make fabrication of reliable, high-strength ceramic components possible. The work using ion implantation and lasers to modify ceramic surfaces toughens them by arresting surface-initiated cracks.

For all of this ceramics research, an effort has been made to avoid duplication of effort throughout DOE by coordination through the DOE Energy Materials Coordinating Committee, Subcommittee on Structural Ceramics. This subcommittee has made a compilation and analysis of all structural ceramics research underway in all DOE programs having structural ceramics research components. This analysis is available upon request and shows quite clearly the major areas of focus and complementarity of the various DOE programs. Avoidance of duplication with other agencies, such as DARPA, continues to occur by information exchanges such as those which take place at the annual Interagency Coordination Meeting on Ceramics for Heat Engines. This coordination notwithstanding, efforts will be made in FY 1987 to effect the orderly transfer of ECUT-initiated ceramics research to the Ceramic Technology for Advanced Heat Engines program in the Office of Transportation Systems and to phase out ECUT's involvement in this most important area of materials research and development.

Materials-By-Design

The present practice of energy conversion system designers is to select materials on the basis of their appropriate performance characteristics and cost. In general, materials are screened on a trial and error basis to see how well they perform in a component or system of interest (e.g., engine, heat exchanger, etc.). Although such testing will always be necessary, the selection of candidate materials on the basis of fundamental physical quantities common to all materials (e.g., the structure and bonding of the atoms or molecules in the material) is not done yet and could lead to the design of totally new and improved performance materials. In order to design materials it is necessary to understand the relationship of the desired properties (e.g., ductility) and performance characteristics (e.g., high-temperature survivability) to the structure and bonding taking place and the role of defects in the material. Given such understanding, a hierarchy of structural and bonding models can, in principle, be constructed to predict the properties to be expected of any given assembly of atoms or molecules. In FY 1984 ECUT initiated an assessment of the state-of-the-art of these models and to provide feedback on further modeling research needs for resolution by basic researchers.

Areas where this materials-by-design approach may be helpful are in the formulation and development of new high-temperature alloys, coatings, and polymers.

Actual research was begun in FY 1985 to capitalize on advances in theory and experimentation coming from basic materials research sponsored by the DOE Office of Basic Energy Sciences. The approach is to apply to materials design problems a combination of the unique experimental and theoretical tools put in place by this same basic research program at the DOE national laboratories in a concerted effort to make use of basic knowledge of the relationship between bonding and structure at the atomic level to selected materials related problems of importance to energy conservation. Application to interfacial phenomena, e.g., adhesion of coatings to substrates, catalytic mechanisms, grain boundary bonding in intermetallic alloys, and bond energies at tribological surfaces are particularly important to energy conservation. In FY 1987 research will be continued to model trial structures of grain boundaries in Ni_3Al with the goal of applying knowledge gained to design new and different intermetallic alloys.

The potential economic importance of this initiative may be seen by a brief consideration of the fact that for just the binary intermetallic alloys (those composed of only two basic elements like nickel and aluminum) there are over 3,700 possible combinations. Each combination potentially represents a totally new material such as the Ni_3Al discussed above. In order to screen and try out each and every one of these 3,700 alloys would be a very expensive and time-consuming task. However, if reliable computer models were available to predict the most promising combinations, only these few would actually have to be tested and experimentally proven in the laboratory.

Catalysis/Biocatalysis $2,400,000

The FY 1987 request for the ECUT Biocatalysis Program is $2,400,000, a decrease of $192,000 from the FY 1986 appropriation. This level of funding will maintain research already underway in bioprocess engineering.

An Office of Technology Assessment (OTA) report, "Commercial Bio-Technology, An International Analysis," stated in the foreword:

> Although the United States is currently the world leader in both basic science and commercial development of biotechnology, continuation of the initial preeminence of American companies in the commercialization of biotechnology is not assured. In the next decade, competitive advantage in areas related to biotechnology may depend as much on developments in bioprocess engineering as on innovations in genetics...and other areas of basic science.

The OTA report essentially identified bioprocess engineering applied research as the weakest link in the U.S. biotechnology research effort.

ECUT recognized this deficiency in support for generic applied bioprocess engineering some 5 years ago and for this reason has been focusing its efforts on bioprocess engineering research.

Bioprocess Engineering

With the advent of recombinant DNA techniques for engineering specific capabilities into microorganisms, it became possible in principle to produce enzymes (biocatalysts) on demand for carrying out specific chemical reactions. ECUT focuses on resolving major generic technical barriers (such as lack of kinetic data and scale-up equations) that impede the use of genetically engineered microorganisms to carry out biologically catalyzed (biocatalyzed) continuous chemical production processes. Such processes have the potential to save process energy not only because of the ability of biocatalysts to carry out exactly the desired chemical reaction in one step (thereby avoiding large energy inputs for intermediate product purification and separation) and at the mild reaction conditions prevailing in biocatalyzed reactions but also to make use of renewable or more abundant feedstock than conventional chemical processes.

A typical problem being researched in genetically engineered microorganisms is the stabilization of the genetic information which has been inserted to make the organism produce desired chemicals. Usually some of this information is lost each time the microorganism divides. While this loss of genetic information is not a great problem in bench scale (1 cubic meter size) fermenters, it can be a major problem for industrial scale (1000 cubic meter size) continuous processes where the microorganisms reproduce millions of times, perhaps to the point where in a very short time none of the useful genetically engineered microorganism is left. This is just one example of the kinds of problems encountered by biochemical engineers who want to design and scale up biocatalyzed production processes; ECUT has made major strides in solving this particular problem by inserting the desired genetic information directly into the cellular chromosomes where it cannot be lost upon cell division.

In FY 1987, work will be maintained on innovative bioreactor designs for biocatalyzed chemical production processes. These innovative approaches to carrying out biochemical reactions hold the promise of overcoming some of the problems which have prevented biochemical production processes from competing economically and energetically with conventional chemical processes. Some of these problems are: slow reaction rates, low yields, and low productivity of conventional batch fermenters. Already ECUT research on one concept has resulted in a potential 80-fold increase in bioreactor productivity over such conventional batch fermenters.

Tribology $2,400,000

The FY 1987 request for the ECUT Tribology Program (the multidiscipilinary science of friction, wear, and lubrication) is $2,400,000, a decrease of $1,355,000 from the FY 1986 appropriation.

The foundation for the long-range plan of the ECUT Tribology Program is a series of detailed analyses that determined energy losses due to a poor understanding of tribology in the transportation, industrial, residential, and utility sectors. Considering that approximately 72 quads of energy are used in the United States each year, these losses are quite sizeable: up to 0.15 quad could be saved in the aggregate in the mining, agriculture, foodprocessing, chemicals, pulp and paper, primary metals, and metalworking industries; up to 0.5 quad could be saved in the utility sector; and up to 2.8 quads could be saved in the transportation sector. While transportation obviously has the greatest losses, the generic nature of ECUT research permits considering automotive applications in the context of the temperatures at which a heat engine operates, and as a result, the needs of many industrial applications can be easily tied together with automotive research needs.

The major approach of this tribology research is to explore innovative lubrication concepts and novel surface modification techniques that mitigate friction and wear in present-day and advanced energy conversion and utilization devices. In this manner, it may be possible to effect major energy savings in the U.S. economy. What makes this program unique is that it is a directed basic research program: it spans the gap between the basic research funded by the DOE Office of Basic Energy Sciences and the engineering development work funded by the Conservation and Fossil Energy offices. Cost-shared projects with these DOE offices are one means of developing and strengthening the technology base and transferring the technology to users. The major output of the ECUT Tribology Program is the development of standardized test procedures, data for the design of advanced mechanical systems, and state-of-the-art analytical equipment used to carry out cutting edge research on real world tribological systems.

Lubricants

ECUT tribology research answered the question in FY 1985 as to why various lubricating base stock oils perform differently with identical additive packages, an inconsistency in behavior that has hindered advancement in lubricating technology. The compounds in base stock oils that interact beneficially with the lubricant additives have now been identified, and that knowledge was transferred in late FY 1986 to the lubricant and additives industry by means of a workshop with researchers in those industries. This understanding opened up a whole new avenue in additive formulation chemistry because some of these base oil compounds can now be investigated as new additives for friction, wear, and oxidation control. As sources of crude oils that are suitable for base stock oil production become depleted, the results of this research will become even more important. Efforts in FY 1987 will build on this work, which dealt with low-temperature (up to 200°C) liquid lubricants, and use it as a foundation for research on liquid lubricants for elevated (200°-600°C) temperatures. Liquid lubricants for the elevated temperature range are viewed by the tribology community as a major technological challenge and a limiting technology to advanced heat engines.

Efforts began in FY 1986 to carefully define the precise tribological conditions existing in machine elements, such as bearings, gears, and engine components, so that development of in-situ diagnostic techniques to study lubricant interaction could begin in FY 1987. This work is important because a better understanding of the lubricant conditions in actual working machine elements will enable designers to develop predictive models for lubricant failure and thereby avoid tribological problems in mechanical equipment.

In FY 1985 a final report on high-temperature (greater than 600°C) lubrication needs for advanced heat engines was used to develop a comprehensive plan for this area of research. The main conclusion of the report was that the full potential of ceramic components for advanced heat engines cannot be realized unless associated tribological advances are made. The long-range plan, therefore, calls for developing new and/or improved laboratory scale tests capable of differentiating between high-temperature thermal-oxidative stability and deposition characteristics of individual basestocks, additives, and lubricants relative to the machine environment. By advancing the state-of-the-art, ECUT tribology research will enhance the likelihood of development of a low heat rejection, minimum friction engine. Close coordination and joint projects with the DOE/Office of Transportation Systems, the Department of Defense, and the National Aeronautics and Space Administration will continue in this area in FY 1987.

Mechanisms of Friction and Wear

Research funded by the ECUT Tribology Program over the past several years in the area of understanding the friction and wear characteristics of ceramics is now paying off. The DOE Office of Transportation Systems is using the technology base developed by ECUT to aid in determining which ceramics to use in advanced heat engines, and the new theory of wear of ceramics developed by ECUT has enabled that Office to understand better what happens under the actual operating conditions of such engines. Because the major problems seem to be solved, ECUT funding in FY 1987 will be used to complete contracts on the mechanisms of friction and wear of ceramics and to close out research in this area.

Friction and Wear Testing

Preparatory to beginning a new research thrust in FY 1986, a workshop was held in FY 1985 that was the first of its kind. The Workshop on Tribological Test Devices and Procedures for Ceramics brought together almost 100 scientists and engineers from 5 different countries. The consensus of the attendees was that the time had come to develop standardized friction and wear tests in order to ensure comparability of data. As a result of this workshop, international cooperation was enhanced in FY 1986 by the fact that ECUT researchers actively participated in a round robin series of friction and wear tests under the sponsorship of the European Economic Community. Again, the results of these tests will be used to determine how to develop standardized test procedures.

Also in FY 1986, the ECUT Tribology Program had coordinated with the American Society for Testing and Materials (ASTM), the American Society of Mechanical Engineers, and others to intitate a program in developing meaningful standardized friction and wear tests for ceramic materials. Test rigs and analytical equipment were used to develop tests that could be certified by standards and professional organizations. Plans for FY 1987 call for approval by ASTM of a standardized test and further development of standardized test procedures for materials other than ceramics, such as ceramic coatings.

Tribological Coatings

Increased energy savings and productivity can be gained by surface modification research for tribological applications because a treated surface can be made harder and more durable than an untreated material. The approach used by the ECUT Tribology Program has been to develop theoretical models of how a cutting tool chemically dissolves into the workpiece and then to conduct experiments to validate the models. So far, the research has been extremely successful because surface modification of conventional high-speed tool steels has brought about wear-resistant surfaces that are 10 times harder than commercially available surface-modified cutting tools. Costs to manufacture such tools are expected to be only about 20 percent more expensive for a 10-fold increase in tool life.

Plans for FY 1987 call for developing even more advanced coatings that are 50 times harder than the most advanced cutting tools, again with a modest increase in cost. The potential application is for bearings, cutting tools, gears, and farm machinery. One of the reasons for the success of this research has been the consortium of two universities, a national laboratory, and a cost-shared industry team that will enable technology transfer into the marketplace to be readily effected.

Results gained from tribological surface modification research in FY 1986 laid the foundation for a transportation-related thrust in FY 1987. Surface modification techniques will apply the theoretical tools developed in the cutting tool research to the more technically difficult area of the piston ring-cylinder liner interface in heat engines. This is an area where generic research from one field (industrial cutting tools) can be used in another (transportation). Another success from this research is the development of advanced characterization techniques that enable the surfaces to be exactly tailored to meet a specific need.

Tribological Design Tools

Several workshops were sponsored by private sector groups and foreign governments during FY 1985 to develop agendas for tribology research. The Canadian government, which recently started a program in tribology modeled after the DOE/ECUT program, feels strongly that an information system that includes tribological data would be invaluable to designers of mechanical components and systems. Further reinforcement for such a computerized data retrieval system was given by the Industrial Research Institute, an organization of over 200 directors of major industrial research laboratories. Among the top three items in their research agenda was again a data retrieval system.

It is apparent that there is a Government role here to serve as the expediter of technology transfer. A low-level effort to develop a draft project plan began late in FY 1985 and continued into FY 1986. The plan was developed by bringing information specialist together with tribologists from Canada and West Germany (where efforts had already begun). FY 1987 plans call for completing a review by industrial members and gaining the financial support of the private sector, a whole host of professional societies (American Society of Mechanical Engineers, American Society of Lubrication Engineers, American Vacuum Society, America Ceramics Society, and many others) to cost share the development of a state-of-the-art computer system. Government sponsorship would last for 3 years after which time the system would be supported by the users.

An important design tool will be completed in FY 1987, a computer model that will assist U.S. engine designers in dealing with the problem of out-of-round cylinder bores. When the cylinder bore is not round, the piston rings cannot fit properly, and oil from the sump and combustion gases then mix. This problem contributes to the inability of the engine to reach theoretical efficiency. When the model is completed, it will become widely available for use in designing more efficient internal combustion engines.

International Research Monitoring $100,000

The FY 1987 request for International Research Monitoring is $100,000, a decrease of $40,000 from the FY 1986 appropriation.

The Multi-Sector Conservation Program is also responsible for evaluating and comparing the current status and projected directions of energy end-use and energy conversion technologies funded by foreign nations. This is an important responsibility. ECUT coordinates and integrates DOE foreign commitments through such mechanisms as the International Energy Agency (IEA) and bilateral activities for all of the Conservation Program. Results will aid considerably in guiding research in DOE Conservation efforts toward developing more fruitful and energy-efficient technologies that ensure future U.S. international competitiveness.

FY 1986 activities included the investigation of foreign technology resources apparent in Japan, West Germany, and Sweden. Specific technology information sources were identified, and abstracts were prepared and published in U.S. trade journals. After discussions with DOE Conservation program staff, priority research areas were identified,and the appropriate investigations were initiated. The FY 1987 program will continue with those investigations, albiet at a minimum level of effort.

Conservation Program Analysis and Planning $100,000

The Multi-Sector Conservation Program is taking on new responsibilities for the whole of the DOE Energy Conservation Program in FY 1987. The funding request is for $100,000. Responsibilities providing technical and administrative support for updating and revising the Five-Year Plan, assessing supercomputer needs, and recommending actions to ensure the availability of analytical instrumentation needed to conduct Conservation-related research. Finally, ECUT will provide oversight of research planned in various programs within the Office of Conservation. These funds and the work proposed will fill a gap in Energy Conservation Program coordination which has existed for several years.

In FY 1987 an assessment of the supercomputer needs for all the Conservation and Renewable Energy programs also will be conducted. As the sophistication of the research being carried out in a program increases, so too does the need for high-speed computations. Since one of the prime outputs of the ECUT program is experimentally validated predictive computer models, access to supercomputing capabilities is particularly acute in the ECUT program. Demand for supercomputer time is growing rapidly in the ECUT Combustion Technology, Materials-by-Design, Catalysis-by-Design, and Tribology Programs. However, other Conservation and Renewable Energy Programs, such as Solar Photovoltaics and Buildings and Community Systems, also have need for high-speed computers to simulate solar and building systems. The proposed assessment will identify and quantify to the extent possible the requirements which exist now for high-speed computing in all Conservation and Renewable Energy Programs and will project those needs into the future as the research in these programs progresses.

Energy-Related Inventions

The mission of the Energy-Related Inventions Program (ERIP) is to evaluate energy-related inventions and new concepts offered by the public and to provide assistance to the most promising.

Recent ERIP accomplishments include:

- Developed a commercial-scale process to manufacture aluminum fuel cylinders reinforced with glass filaments for use as automobile fuel tanks. Aluminum Corporation of America (ALCOA) subsequently purchased the development and presently markets the cylinders.
- Developed a process to ship fruits and vegetables without refrigeration in a natural atmosphere which allows them to ripen naturally and extends their shelf life. The initial test item of "Tom-AH-toes" was well received and is now being shipped to a number of East Coast retailers, including Safeway in the Washington, D.C., area.

Energy-Related Inventions Program..$3,300,000

The FY 1987 request for the Energy-Related Inventions Program (ERIP) is $3,300,000, a decrease of $1,353,000 from the FY 1986 appropriation.

ERIP, initiated under the Federal Non-Nuclear Research and Development Act of 1974, provides first for evaluation of inventions by the Office of Energy-Related Inventions (OERI) in the National Bureau of Standards (NBS) of the Department of Commerce (DOC) and then, assistance by the DOE Energy-Related Inventions Program for inventions identified by OERI as promising. The program gives particular attention to small businesses and individual inventors by assisting the NBS-recommended inventors in developing and/or commercializing their inventions. ERIP was established to evaluate the technical merits of energy-related inventions submitted by individual inventors and small businesses and to provide financial and technical assistance to the most promising ideas. Through FY 1985 the National Bureau of Standards (NBS) had evaluated approximately 22,000 energy-saving inventions. Based on NBS recommendations, 224 inventors have been awarded grants totaling $16,100,000. Of these 224, 36 are in the marketplace with sales to date totaling over $155,000,000, and over 1,000 jobs have been created.

In FY 1986 2,000 invention proposals were evaluated with 35 to 40 private sector inventions being approved for further development. A funding level of $3.3 million in FY 1987 will reduce the number of inventions evaluated and support for inventors as well as eliminate continued support for the Innovative Concepts Program formerly funded by the ECUT Program.

National Appropriate Technology Assistance Service

The mission of the National Appropriate Technology Assistance Service (NATAS) is to provide information and consultation assistance to the public requesting self-help in solving energy problems.

NATAS accomplishments over the past year include:

- Responded to 10,184 nationwide requests for tailored information and technical assistance pertaining to engineering and scientific aspects of appropriate technologies and 639 requests for assistance pertaining to business planning, patents, licensing, and obtaining private sector financing for energy-related inventions and businesses.

National Appropriate Technology Assistance Service..............................$750,000

The National Appropriate Technology Assistance Service (NATAS) FY 1987 Congressional request is $750,000, which is $646,000 less than the FY 1986 appropriation. This reflects a general, across-the-board reduction in NATAS activities.

The FY 1987 Congressional request provides for the continuation of some of the services provided by NATAS. NATAS currently provides tailored information responses and engineering, scientific, or technical aid to anyone in the United States who needs to know more about those technologies that lend themselves to self-help and provide solutions to individual energy problems. These "appropriate" technologies usually rely on sun, wind, and water resources and energy and natural resource conservation methods and devices.

The program is most beneficial to small businesses, farmers, homeowners, State and local governments, and nonprofit organizations. NATAS is working closely with existing Federal, State and local programs coordinating technical assistant activities.

In addition, NATAS provides commercialization assistance, i.e., business planning, development and financial analysis, to inventors and entrepreneurs who are attempting to develop and market products utilizing renewable energy sources or designed to conserve energy.

Capital Equipment $100,000

The FY 1987 request for plant and capital equipment is $100,000, a reduction of $830,000 from the FY 1986 appropriation. Funds will be used to continue limited upgrading of outmoded equipment and the acquisition of new state-of-the-art equipment for the ECUT Program at the DOE national laboratories and at Historically Black Colleges and Universities (HBCU's) conducting ECUT research.

Program Direction $500,000

Funding of $500,000 in FY 1987 will provide for 8 full-time equivalents (FTE's) to manage the research described above for the ECUT program, a reduction of 1 FTE from FY 1986.

MISSION AND OBJECTIVES OF STATE AND LOCAL ASSISTANCE PROGRAMS

The goal of the State and Local Assistance Programs is to encourage energy conservation initiatives on the State and local level through a mix of activities and programs, including direct financial assistance, personalized information services, technical assistance, and developmental demonstration projects to enhance State and private sector involvement in energy conservation. The Office of State and Local Assistance Programs administers the following programs in support of its goal:

- the Weatherization Assistance Program;
- the Schools and Hospitals Grants Program, also known as the Institutional Conservation Program;
- the Energy Policy and Conservation Act (EPCA) Grants, also known as the State Energy Conservation Program (SECP); and
- the Energy Extension Service.

The first two programs were established to provide assistance to sectors of the economy which experience particular difficulty in dealing with rising energy costs. The Weatherization Assistance Program increases the energy efficiency of residences occupied by low-income citizens across the country, particularly the homes of the elderly and the handicapped. The Schools and Hospitals Grants Program provides matching grants to non-profit institutions. The EPCA Grants and the Energy Extension Service were established to provide funding to the States and Territories for a variety of comprehensive energy conservation activities, and to build a capacity within and among the States and territories to plan, develop, and carry out their own energy conservation and outreach programs.

These programs have accomplished a great deal. Over 1.5 million low-income homes have been weatherized. Over 19,000 grants have been awarded to schools and hospitals, funding energy conservation projects in some 53,000 institutional buildings. Comprehensive energy conservation programs and information outreach programs are in place in 57 States and Territories, and through these millions of people have been aided in using energy more efficiently.

The FY 1987 budget request provides for the orderly closeout of these programs. Responsibility for providing these services most apropriately resides with the states. It is expected that funds will be made available to the states through the settlement of petroleum pricing violation cases, and these funds will help finance weatherization and other energy-related activities.

Department of Energy
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
State and Local Assistance Programs

Operating Expenses
(Tabular dollars in thousands. Narrative materials in whole dollars)

	FY 1985 Appropriation	FY 1986 Request	FY 1987 Base	FY 1987 Request	Request vs. Base
State & Local					
Weatherization	$191,113	$177,970	$177,970	$ ---	$-177,970
Schools & Hospitals	47,043	43,874	43,874	---	-43,874
EPCA Grants	23,522	17,499	17,499	---	-17,499
Energy Extension Service	9,801	7,297	7,297	---	-7,297
Program Evaluation	1,960	---	---	---	---
Program Direction	9,961	9,525	9,525	5,000	-4,525
Territories Assitance	---	465	465	---	-465
Total, SLAP	$283,400	$256,630	$256,630	$5,000	$-251,630
Staffing					
Total FTE's	178	180		100	-80 FTE

Authorizations:

National Energy Extension Service Act, Title V, P.L. 95-39;
Energy Policy and Conservation Grant Program (Energy Policy and Conservation Act, P.L. 94-163);
Energy Conservation and Production Grant Program (Energy Conservation and Production Act, P.L. 95-385);
Schools and Hospitals Grant Program (National Energy Conservation Policy Act, Sec. 301-304, P.L. 95-619);
Other Local Government Buildings Grant Program (National Energy Conservation Policy Act, Sec. 310-312, P.L. 95-619;
Weatherization Assistance Program Energy Conservation and Production Act, Sec. 411, P.L. 94-385);
Department of Energy Organization Act, P.L. 95-91;
P.L. 93-577, The Federal Non-nuclear Energy Research and Development Act of 1974
P.L. 95-91, Section 301, Department of Energy Organization Act

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1985 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	Gramm-Rudman-Hollings Reduction	Adj. Approp. Total
State and Local						
Weatherization	$191,200	$-1,120	$-4,114	$ ---	$ -7,996	$177,970
School & Hospitals............	47,134	-275	-1,014	---	-1,971	43,874
EPCA Grant	18,818	-129	-404	---	-786	17,499
Energy Extension Service	7,841	-47	-169	---	-328	7,297
Territories Assistance	500	-3	-11	---	-21	465
Program Direction	8,494	-51	-220	1,730	-428	9,525
Subtotal, State and Local...	$273,987	$-1,625	$-5,932	$ 1,730	$-11,530	$256,630
General Reduction:						
Operating Expenses	-1,625	1,625	---	---	---	---
Management Initiatives:						
Operating Expenses	-5,932	---	5,932	---	---	---
Pay Restoration.................	1,730	---	---	-1,730	---	---
Total, State and Local	$268,160	$ ---	$ ---	$ ---	$-11,530	$256,630
Operating Expenses	268,160	---	---	---	-11,530	256,630
Capital Equipment						

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1987 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Gramm-Rudman-Hollings Reduction	Approp. Total
Facilities					
Facilities	$ 10,319	$ -57	$ -222	$ -432	$ 9,608
General Reduction:					
Construction	-57	+57	---	---	---
Management Initiatives:					
Construction	-222	---	222	---	---
Total, Facilties	$ 10,040	$ ---	$ ---	$ ---	$ 9,608
Construction	$ 10,040	$ ---	$ ---	$ -432	$ 9,608

Department of Energy
FY 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF CHANGES
(In thousands of dollars)

State and Local Assistance Programs

FY 1986 Budget Request	$ 256,630
Program Increases and Decreases	
Weatherization Assistance Program - Close out of grant funding	$-177,970
Schools and Hospitals - Close out of grant funding	$ -43,874
EPCA Grants - Close out of grant funding	$ -17,499
Energy Extension Service - Close out of grant funding	$ -7,297
Territories Assistance - Close out of grant funding	$ -465
Program Direction - Supports 80 less FTE	$ -4,525
FY 1987 Budget Request	$ 5,000

ACCOMPLISHMENTS OF THE WEATHERIZATION ASSISTANCE PROGRAM

The Low-Income Weatherization Assistance Program increases the energy efficiency of residences occupied by low-income persons across the country, particularly the homes of the elderly and the handicapped. Since 1977, the program has weatherized over 1.5 million homes with an average home heating energy saving of 13% per home. Most recent specific accomplishments of the program are as follows:

o Revised the program rule to provide increased flexibility to States to develop energy audits and select the most cost effective weatherization techniques. The rule widens the range of weatherization materials which can be considered, and updates standards for them.

o Issued a rental unit weatherization policy to increase weatherization of such dwellings, especially in multi-family buildings.

o Implemented innovative financing projects in four states to demonstrate methods that can be used to increase private sector involvement in weatherizing multi-family structures. In Minnesota, the state is assisting a private landlord in securing the services of a commercial energy services firm. In Pennsylvania, the local community action agency is designing a loan interest reduction plan to accomplish energy conservation retrofit on a building. In New York, the local community action agency is establishing a separate operation as a not-for-profit energy services company to provide services to low-income multi-family buildings. In Michigan, the City of Ann Arbor is acting as a shared savings company, financing building projects from a revolving fund repaid by the savings from the energy conservation retrofits.

o Completed a national evaluation of the energy savings achieved in weatherized homes. As mentioned above, the evaluation shows an average home heating energy savings of 13% in those homes, with 23% of weatherized homes increasing energy use after weatherization.

o Implemented a comprehensive monitoring program to improve the overall quality of workmanship.

o Initiated comprehensive program evaluation activities to measure all impacts of the program.

ACCOMPLISHMENTS OF THE SCHOOLS AND HOSPITALS PROGRAM

The Schools and Hospitals Grants Program, also known as the Institutional Conservation Program (ICP), was established to encourage energy conservation in the institutional buildings sector. Such public and private non-profit institutions use significant amounts of energy, the cost of which represents a large proportion of their operating budgets. As a result, energy conservation measures can result in significant energy and economic savings. Most recent specific accomplishments of the program are as follows:

° From 1980-85, awarded 19,000 grants for energy conservation projects in over 53,000 buildings.

° Energy savings accumulating from ICP-funded projects are estimated to total 50 trillion BTU's per year.

° Energy costs for participating institutions have been reduced: \$.54 for schools and \$.65 for hospitals annually for every \$1.00 invested by the federal government.

° A program data base which contains substantive energy-related data on institutional buildings (size, energy consumption rate, type of building).

° Developed an "Institutional Manager's Guide to Energy Conservation" which has been distributed to institutions, institutional organizations, state energy offices and DOE field offices.

° Developed, with the National Society of Professional Engineers, an " Institutional Managers Guide to Technical Assistance Analysis."

° Through a grant to the American Hospital Association, studied uses of alternate financing and developed guidelines for hospitals.

° Initiated a project to study use of and develop guidelines for alternate financing within communities so that such contracts might be used by the local government, public schools and colleges and universities within the same community.

° Participated in conferences, annual conventions and with energy committees of national professional associations and societies to multiply program efficiency and impact.

° Initiated in late 1984 a strategy development process to identify ways of compounding the impact of the ICP grant program by systematically incorporating more non-federal resources and expertise in institutional energy efficiency. Developed during 1985, through a process of broad-based research, analysis, coordination, and consultation, a strategy which addresses the three most important energy-related needs of institutions, (financing, expertise, and information) as identified during the course of interviews and focus group meetings. The strategy was approved by the Assistant Secretary for Conservation and Renewable Energy during September, 1985.

° ICP and several States are working on a variety of initiatives to encourage institutions which have applied for, but not received, ICP grants, to seek alternative, innovative sources of funding for energy efficiency improvements.

The following are examples of what grantees have accomplished with funds provided by ICP:

° ICP funds have supplemented Ohio State University's energy conservation efforts, which save the university approximately $5.5 million per year. University officials believe that without their energy conservation program tuition costs for each student would be about $100 per year higher. ICP has funded projects in 15 campus buildings since 1980.

° A Nevada high school installed the second of three evaporative coolers. The energy-efficient system, which saved over $28,000 in energy costs during its first year of operation, received a Special Award in the Department of Energy's 1985 technology-transfer competition, and was funded in part by an ICP grant.

° ICP funds have supplemented the Washington, D.C., Children's Hospital energy conservation efforts through the installation of pneumatic controls which are projected to save the hospital more than $100,000 per year.

° Cooper Green Hospital in Birmingham, Alabama, issued an ICP grant as seed money to leverage an additional $377,000 of private financing which, combined, saved 2-3 times the energy ICP dollars alone could have achieved.

ACCOMPLISHMENTS OF THE STATE ENERGY CONSERVATION PROGRAM

The State Energy Conservation Program (SECP) was created in 1977 to provide financial assistance to states for the purpose of supporting state and local conservation projects. The legislation authorizing the SECP requires that States carry out programs in five areas:

1. Mandatory lighting efficiency standards for public buildings (except public buildings owned or leased by the United States).

2. Programs to promote the availability and use of carpools, vanpools, a public transportation (except that no Federal funds provided under this part shall be used for subsidizing fares for public transportation).

3. Mandatory standards and policies relating to energy efficiency to govern the procurement practices of a state and its political subdivisions.

4. Mandatory thermal efficiency standards and insulation requirements for new and renovated buildings (except buildings owned or leased by the United States).

5. A traffic law or regulation which, to the maximum extent practicable consistent with safety, permits the operator of a motor vehicle to turn such vehicle right at a stop light after stopping.

o The South Dakota Housing Development Authority recently adopted the state's first Energy Conservation Code, for new and existing housing. The energy saving rules were developed by the South Dakota Energy Office.

o The state of Alaska has made available through the State Energy Conservation Program (SECP), 75 Energy Tellers which are used to measure, in dollars, the electrical consumption of plug-in type appliances or other electrical devices for 120-volt AC devices. They are offering Energy Tellers to all electrical utilities in the state for their customers' use. Requests for 42 of the Tellers have been received from utilities.

o The Florida Energy Office assisted the legislature in its 1985 regular session by addressing energy conservation in three key bills. Passed during the session were: (1) One bill encourages state agencies to consider "shared savings financing" for energy conservation retrofits and maintenance services provided by private firms. The firms would own any purchased equipment for the duration of the contract, not to exceed 10 years, and would be recompensed out of the savings. (2) New legislation also requires a life-cycle cost analysis on high energy-use replacement equipment for buildings owned or leased by the state. In the past, such equipment as air conditioners, heaters, and water heaters were chosen on the basis of lowest bid. (3) Ridesharing is promoted by a bill that provides reserved parking spaces free for state employee car pools.

o The North Dakota Office of Intergovernmental Assistance has established a computer program which analyzes costs and potential savings in street lighting systems for smaller communities. The program is contained on three diskettes designed to run an IBM-PC. It determines current operating costs, computes potential costs, savings of converting to high pressure sodium lights, and computes potential savings from reducing the hours of operation.

o The District of Columbia Energy Office sponsored a series of energy conservation workshops under the auspices of the SECP which focused on a variety of different sectors within the city. Workshops have been conducted for operations of the Blue Plains Wastewater Treatment Plant and for building design professionals (architects and engineers). Additional workshops include training sessions for owners, operations, and managers of commercial office buildings and an advanced course for building design professionals.

ACCOMPLISHMENTS OF THE ENERGY EXTENSION SERVICE

The Energy Extension Service (EES) was established to connect energy users - such as homeowners, tenants, landlords, small business and local governments with practical conservation and renewable resources options available to them. The EES was modeled after the highly successful Agricultural Cooperative Extension Service. Grants are given to States to implement EES programs and to deliver services to their energy users. States are given broad flexibility in designing programs to meet their particular needs. The service as established will provide the national infrastructure for the transfer of new technologies as they become available. Examples of types of programs that States are running are:

o The Youth Energy Conservation Corps (YECC) is a program element of the West Virginia Energy Extension Service. The goals of the program are: (1) to elicit an increased response rate to the Residential Conservation Service energy audit program and (2) provide youths with part-time employment to develop job skills. The West Virginia 4-H program was selected as the organization to operate the program in cooperation with the West Virginia University Center for Extension and Continuing Education. During the first program year, 1,219 audits were conducted by 700 youths in seven counties. Ninety-five percent of the households participating had never previously participated in an energy audit. Fifty-nine percent initiated at least one of the recommended measures. Overall, 78 percent of all participating households felt the audit program useful and 65 percent felt that changes in their lifestyles were made as a result of the audit.

o The Alabama Energy Extension Office has developed the "Car Kit" which consists of eight Apple computer programs on three diskettes, five color video programs (for a total of 27 minutes) on 1/2" VHS cassetts tape, car owner's handbook and a teacher's guide. The Car Kits distributed free of charge to the first 100 schools in Alabama requesting them, will then be available for a nominal fee. Developed for driver education classes, libraries or general classroom use, the Car Kits can be used to teach students about computers while at the same time offering relevent material concering car operation, maintenance, and energy conservation. The Car Fitness Book is a reference guide to car maintenance and energy efficiency conveniently sized to fit the car's glove compartment. It provides practical information on driving techniques, car maintenance, and energy conservation. The transportation videos consist of a series of five videos on one 1/2" VHS tape. They deal with safe driving practices, car care, and saving energy. The transportation conservation microcomputer software consists of a series of eight programs on three disks.

o Massachusetts Energy Office Energy Extension Service has recently begun the second phase of its Energy Employment Training Program. This program's goal is to increase employment opportunities for low-income, urban, and minority heads of household through employment training in an energy-related industry. A grantee of the State Energy Office in the city of Boston is currently recruiting eligible individuals to train as entry-level heating, ventilation, and air conditioning technicians. Once recruited, the individuals will be trained and placed in appropriate jobs. It is the hopes of the Massachusetts Energy Office that once this phase of the program is completed, the Energy Employment Training Program will be replicated in another part of Massachusetts.

Department of Energy
FY 1987 CONGRESSIONAL BUDGET REQUEST
State and Local Assistance Programs

NARRATIVE JUSTIFICATION

The goal of the State and Local Assistance Program is to encourage energy conservation initiatives at the State and local level through a mix of activities and programs, including direct financial assistance, technical assistance, and developmental/demonstration projects to enhance State/private sector involvement in energy conservation. In FY 1987, program efforts will be directed toward the orderly close-out of the State Energy Conservation (EPCA), Energy Extension Service, Schools and Hospitals and Weatherization Assistance Programs. Responsibility for providing these services most appropriately resides with the States. It is expected that funds will be made available to the States through settlement of petroleum pricing violation cases, and these funds will help finance weatherization and other energy-related activities.

Weatherization	FY 1985	FY 1986	Congressional Request FY 1987
	$191,113,000	$177,970,000	-0-

The FY 1987 Budget request provides no funding for Weatherization. This represents a $177.9 million decrease from FY 1986.

The Weatherization Assistance Program increases the energy efficiency of residences occupied by low-income citizens across the country, particularly the homes of the elderly and the handicapped.

It is estimated that approximately 14.4 million households at or below 125% of poverty are eligible to receive assistance under this program. Low-income households are least able to respond effectively to the market signal of higher prices by making energy conservation investments. As of December, 1985, approximately 1.5 million low-income homes were weatherized under this program.

Because over half of the eligible population lives in rental and multifamily units, increased emphasis has been placed on weatherizing these dwellings. To assist in increasing the impact on the low-income multifamily building sector, several innovative financing demonstrations have been undertaken to explore options available to State and local program operators, landlords, and private sector financial institutions.

Also, the program has taken the initiative in identifying and developing alternative approaches to providing weatherization services to the low-income. During the last half of FY 85 and through FY 86, the program is:

- promoting quality workmanship at the local level through quality control systems established by the States;
- ensuring program efficiency through site monitoring visits;
- conducting program evaluation activities to determine the best approaches to maximizing weatherization resources;
- conducting national and regional conferences to share program information, state-of-the-art weatherization techniques and management strategies; and
- developing and implementing a program to provide program opportunity grants to States and local agencies to promote energy related business development activities by local agencies.

Amendments to the program regulations have given the States more flexibility and responsibility in operating their respective programs. This will allow the State and local agencies to respond best to local needs.

In FY 1966, the program will examine what services should be provided and how best to provide those services given limited Federal funding. This examination will result in the development of a multi-year strategy aimed at broadening and diversifying the weatherization resource base in order to accomplish program goals.

In FY 1987, DOE will continue limited work with States and local agencies to encourage innovative financing of low-income weatherization activities, while closing down the financial assistance aspects of the program.

Schools & Hospitals	FY 1985	FY 1986	Congressional Request FY 1987
	$47,043,000	$43,874,000	-0-

The FY 1987 budget request provides no funding for the Schools and Hospitals Grant Program. This represents a $43.8 million decrease from FY 1986.

The Schools and Hospitals Grant Program was established to encourage energy conservation initiatives in the institutional building sector. Such public and private non-profit institutions use significant amounts of energy, the cost of which represents a large proportion of their operating budgets. As a result, energy conservation measures can result in significant energy and economic savings.

Through FY 1985, the program awarded 19,000 grants for energy conservation projects in over 53,000 school and hospital buildings. The program has also had notable secondary effects in stimulating energy-saving activities and developing expertise in energy conservation in participating institutions.

The program has taken the initiative in identifying and developing alternative approaches to promoting energy conservation in the institutional building sector. During 1985, through a process of broad-based research, analysis, coordination and consultation, a multi-year program strategy was developed to address the three most important energy-related needs of institutions, (financing, expertise, and information) as identified during the course of interviews and focus group sessions. In FY 1986, the program will implement its multi-year strategy to:

- continue demonstrating various alternative energy conservation financing methods to increase private sector support of energy conservation in institutions;

- conduct enhanced information development networking activities and demonstration projects in partnership with national associations, state and local governments, and other Federal programs which will focus on providing products and services such as energy management and financing case studies, data on successful energy efficiency programs and projects, and to provide data and referrals to assist institutions with energy management and financing concerns.

Also, as part of it's strategy implementation, ICP will use a portion of the appropriation for developmental grants to provide seed money for states to assist their non-profit institutions to access alternative sources of financing energy conservation and share energy management information and expertise.

In FY 1987, DOE will continue limited work with States to encourage innovative financing of priority projects and to share energy management information and expertise with institutions while closing down the financial assistance aspects of the program.

EPCA Grants	FY 1985	FY 1986	Congressional Request FY 1987
	$23,522,000	$17,499,000	-0-

The FY 1987 budget request does not provide funding for the EPCA grants. This represents an $17.4 million reduction from FY 1986.

SECP has provided states with the means to plan, establish and implement energy conservation programs that reduce energy consumption in each state. Fifty states and seven territories have developed energy efficiency plans, and are implementing and evaluating specific programs.

SECP has supported the states in the development of conservation and renewable resources activities that address the specific energy issues of each state. The states have also developed and are maintaining an energy emergency planning and response network, a database of information on energy use and energy conservation efforts statewide, and state-wide "networks" of organizations involved in energy activities.

In FY 1985 DOE focused on ways to help the states increase their involvement in the planning and financing of their energy programs. In FY 1986, DOE will work extensively with states to increase their program planning, evaluation, and financing skills, and to seek out and encourage private sector investment in energy efficiency activities.

In FY 1987 DOE staff will continue to work in a limited fashion with the states providing training and technical assistance. However, no financial support will be provided to enable the states to develop and implement plans for obtaining increased private sector funding, since the grants aspect of the program terminates this year.

Energy Extension Service	FY 1985	FY 1986	Congressional Request FY 1987
	$9,801,000	$7,297,000	-0-

The FY 1987 budget request provides no funding for the Energy Extension Service (EES). This represents a $7.3 million reduction from FY 1986.

Through the States EES has provided tailored information, and technical assistance to small scale energy users (i.e small businesses, local governments and homeowners) to help them decide what are their most effective and productive energy conservation and renewable energy options.

The demonstration of commercially available technologies/techniques, hands-on workshops, on-site technical assistance and "how-to" workbooks are the principal methods utilized by EES to meet the needs of the energy consumer. EES has functioned as an integrating and coordinating mechanism for existing resources and delivery mechanisms, providing them with new/updated information and backing them with sound technical advice. EES has also provided a referral service to assist energy consumers.

In FY 1985, DOE focused on ways to help the states increase their involvement in the planning and financing of their energy programs. In FY 1986, DOE will work extensively with states to increase their program planning, evaluation, and financing skills, and to encourage private sector investment in energy efficiency activities, as well as the networking of technical resources to support their programs.

In FY 1987 DOE will continue to work, in a limited fashion, with the states providing training and technical assistance. However, no financial support will be provided to states to develop and implement plans on obtaining increased private sector involvement, since the grants aspect of the program terminates this year.

Territories Assistance	FY 1985	FY 1986	Congressional Request FY 1987
	$ -0-	$465,000	$ -0-

The FY 1987 budget request provides no funding for Territories Assistance. This represents a $465,000 decrease from FY 1986.

In FY 1986, DOE will provide small grants to the Territories to aid them in developing their idigenous energy resources, as an alternative to conventional energy sources which must be imported to the islands.

There are no funds requested for this activity in FY 1987.

Program Direction	FY 1985	FY 1986	Congressional Request FY 1987
	$9,961,000	$9,525,000	$5,000,000

The FY 1987 budget request for Program Direction is $5 million, a reduction of $4.5 million from FY 1986.

The staffing level for program direction in FY 1987 is 100 FTE. This FTE request will support personnel in headquarters and in DOE's field offices to provide for orderly closeout of the financial aspects of these programs.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
POLICY AND MANAGEMENT
Energy Conservation - Operating Expenses

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Approp.	FY 1986 Adj. Approp.	FY 1987 Base	FY 1987 Request	Request vs. Base
Energy Conservation					
Policy and Management Operating Expenses	$ 1,747	$ 1,687	$ 1,687	$ 1,792	+105
Total Policy and Management	$ 1,747	$ 1,687	$ 1,687	$ 1,792	+105
Staffing Total FTEs	28	21	21	17	- 4

Authorization: Section 209 P.L. 95-91, "Department of Energy Organization Act."

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	Management Initiatives	Pay Cost Restoration	Gramm-Rudman-Hollings Reduction	Adj. Approp. Total
Policy & Management - CE (EC)						
Policy & Management	$ 1,300	$ -8	$ -39	$ 510	$ -76	$1,687
General Reduction	-8	+8	---	---	---	---
Management Initiatives	-39	---	39	---	---	---
Pay Restoration	+510			-510	---	---
Total, Policy & Management	$ 1,763	$ ---	$ ---	$ ---	$ -76	$1,687

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
POLICY AND MANAGEMENT
(In Thousands of Dollars)

FY 1986 Adjusted Appropriation	$1,687
Increased level of support	+105
FY 1987 Congressional Request	$1,792

Policy and Management	$1,792,000

The Policy and Management FY 1987 Congressional Request is $1,792,000 and 17 full time equivalent staff years of effort which provides for overall management guidance to Conservation and Renewable Energy (CE) programs. Staffing levels provide the executive and overall program direction for all CE programs to ensure effective management. These activities include executive management, policy formulation, program review and approval, and liaison with senior officials in DOE, White House, Congressional, OMB, other Departmental Agencies, private industry, and State and local governments. In addition, the staff will carry out analyses of the CE programs needed to assess performance and effectiveness.

The FY 1987 request also provides for a minimal level of support for functions such as planning, policy development and analysis, program planning and evaluation, budget preparation and execution, program and personnel management and administrative support. Activities performed include development of planning guidance, analysis of program options for achieving planned objectives, evaluation of performance against program objectives, handling and/or coordination of program/budget submissions and execution of approved budgets and ongoing support functions in the areas of: administrative services, procurement, personnel, space management and related support services including a comprehensive program review function. In addition, funds are included for the continuation of a procurement tracking system and an automated support system which provides text processing, electronic mail, data base management, communication and other program applications.